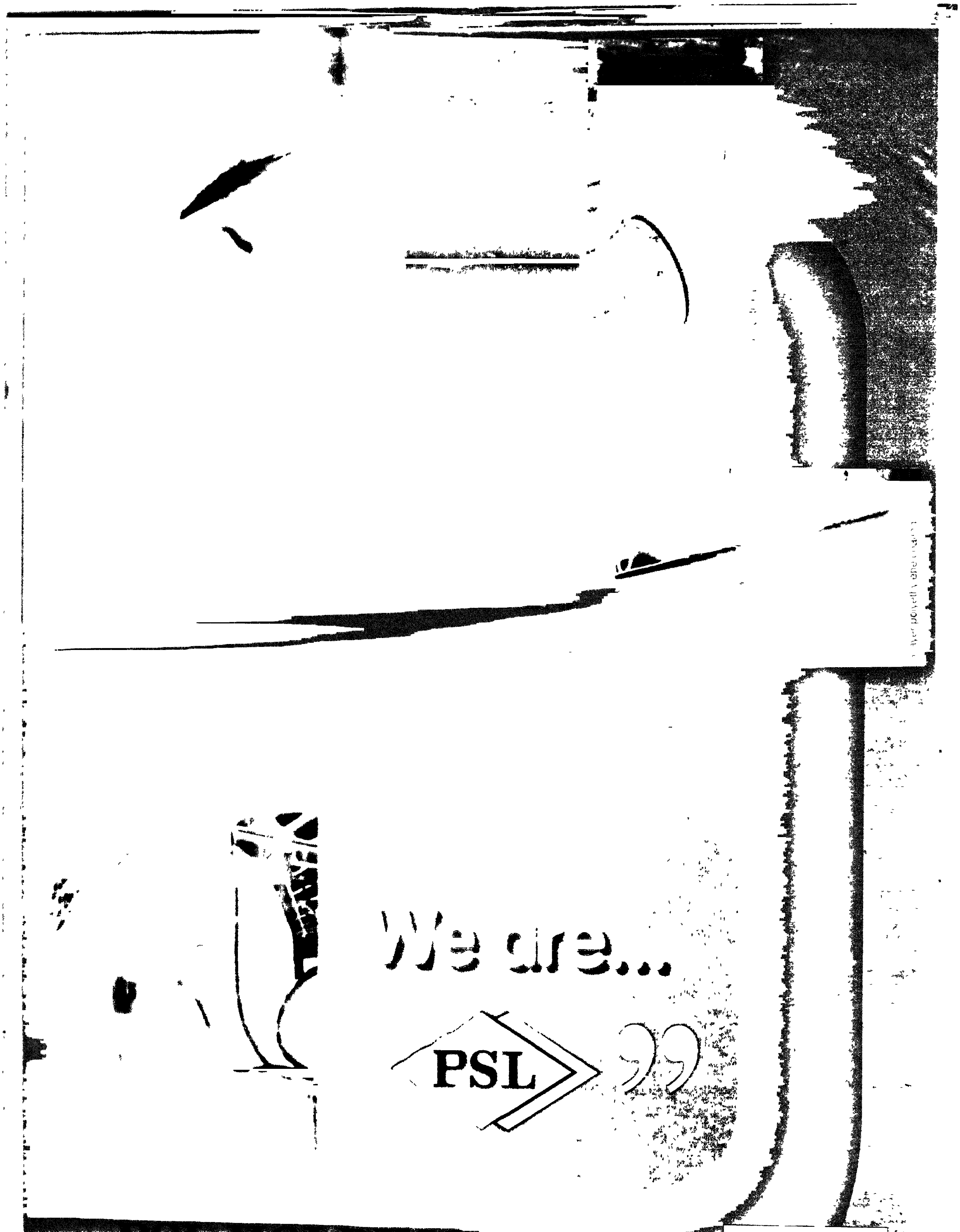
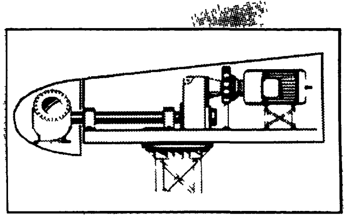


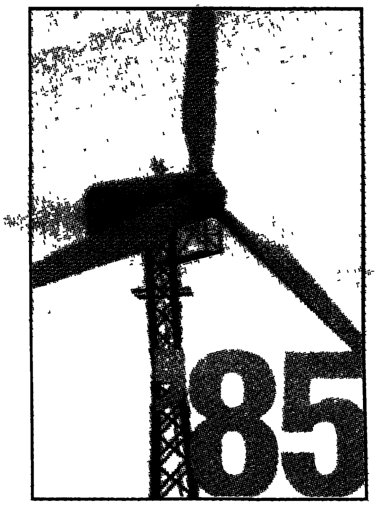
PSL HOLDINGS LTD.

MEMBER

WIND ENERGY MADE MORE [illegible]

Enercon - Conventional Gear
Wind Mills made till 1985





E30 230 kW

Gearless Types

Producing Power at Highest
"Plant Load Factor"

REASONS FOR GETTING HIGHEST PLF :

- Variable Speed Drive.
- Continuous Variable Pitch Regulation.
- Starts Generation at lowest wind speed of 2.5 Mts. per second.
- Saves the transmission losses due to Gearless construction.

GRID FRIENDLY FEATURES :

The ENERCON Synchronous Generator draws less than One Percent Reactive Power from Grid as against Induction Generator in Conventional type Wind Mills which draws 50 to 60% minimum.

[illegible]ING AC - DC - AC CONVERSION :

- [illegible]ps the Power at "Grid Frequency."
- F[illegible]ce power at all the loads at near Unity Power Fa[illegible] without using capacitors.
- Sup[illegible] Reactive Power to the Grid to improve Grid Pow[illegible]ctor.

LONG [illegible]

- Less W[illegible] & Tear as the Gearless construction eliminate [illegible]ear Box and many rotating parts.
- Slow Spee[illegible]enerator of maximum 50 rpm.
- Three indep[illegible]ent Air Breaks and no mechanical breaks.
- Lightening pro[illegible]ion for the Blades also.

ISO
9002

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INDIA

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Preface

TEDDY (TERI Energy Data Directory & Yearbook) as a publication has become an important source of information and analysis on the energy and related sectors in India. In these days when there is a worldwide move towards exchange of data through the Internet and developments that essentially enable those looking for information to gain access through cyberspace, one could question whether continuation of the production of hard copies of TEDDY is really a step in the right direction. However, the demand for TEDDY has continued to grow, largely because even though pieces of information can be searched and accessed through the Internet, it is a great convenience to have a hard copy volume available on a person's desk. Hence, the major reason why the utility for TEDDY continues to grow lies in the fact that, firstly it is far more user-friendly to have a volume on one's desk wherein you can quickly thumb through pages to see exactly what data is required and what is available in relation to the demand for a piece of information. And, secondly because often one needs just one or two sets of numbers in the course of preparing a report or putting together a paper, it is easiest to quickly thumb through the pages of TEDDY and pick out the specific number or numbers that are required for a particular purpose.

It must, however, be emphasized that TEDDY is not a static publication. Even though its format and general layout have remained consistent throughout the years, it has attempted to provide information in a form and content that would enhance its utility and usefulness over successive issues. The feedback received from readers and users of TEDDY has always been valuable in reshaping the exact content and nature of this document. It is hoped that the current volume would serve a need consistent with current requirements for information on energy and related sectors in the Indian economy. It is also useful to mention that TERI is offering updated information and data on the various subjects and contents that are included in TEDDY online as well. Information on the availability of this electronic version of data from TEDDY (called TEDDY Online+) can be obtained from Information Dissemination Services of TERI by sending an e-mail to **outreach@teri.res.in.** We believe that TEDDY Online+ ensures greater use and utility of the database that exists at TERI.

Several persons have contributed to the compilation of the current volume of TEDDY, but in particular, Ms Gurneeta Vasudeva's name needs to be singled out for her enormous dedication, application, and drive. This helped to ensure that all the various components of the information reported in TEDDY are carefully updated by accessing a variety of sources both in India and overseas and that the gremlins and glitches that often appear in a publication of this nature are carefully eliminated and any inconsistencies remaining also carefully removed. It needs to be appreciated that since various elements of energy data come from a variety of sources, there is always the danger of inconsistencies which creep in and which in a single volume such as TEDDY would certainly not be acceptable. The team that has worked on TEDDY, therefore, has ensured at every stage that a consistency check is carried out for all the various tables and time series data provided in different components of the compilation presented. Needless to say, several other persons have worked very hard to ensure that TEDDY keeps not only to standards set earlier, but actually exceeds them, and that the usefulness and the ease of accessing information provided in TEDDY is further enhanced this year over and above the volumes published in previous years. The persons who deserve acknowledgement and appreciation for their efforts in this context are Ms Ritu Jain, Ms Ramela Shanthi, and Mr K P Eashwar.

R K Pachauri
Director, TERI

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List of abbreviations / acronyms

AAI	Airports Authority of India
ABE	Advisory Board on Energy
ADB	Asian Development Bank
AFC	actual forest cover
AIJ	activities implemented jointly
ALGAS	Asia Least-cost Greenhouse Gas Abatement Strategy
APM	administered pricing mechanism
ASTRU	Association of State Road Transport Undertakings
ATF	aviation turbine fuel
BALCO	Bharat Aluminium Company Limited
BAU	business as usual
BCAS	Bureau of Civil Aviation Security
BCCL	Bharat Coking Coal Limited
BCM	billion cubic metre
BCPPs	biomass combustion-based power projects
BF-OH	blast furnace-open hearth
BHH	Bayer-Hall-Heroult
BICP	Bureau of Industrial Costs and Prices
BOFs	basic oxygen furnaces
BOLT	build-own-lease-transfer
BOO	build-own-operate
BOOT	build-own-operate-transfer
BOVs	battery-operated vehicles
BPCL	Bharat Petroleum Corporation Limited
BRPL	Bongaigaon Refinery and Petrochemicals Limited
BSI	Botanical Survey of India
BSMDCL	Bihar State Mineral Development Corporation Limited
CARG	compounded annual rate of growth
CASE	Commission for Additional Sources of Energy
CAZRI	Central Arid Zone Research Institute
CBD	Convention on Biological Diversity
CBP/IBP	community biogas plants/institutional biogas plants
CCL	Central Coalfields Limited
CDM	clean development mechanism
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CICP	Committee on Integrated Coal Policy
CIF	cost insurance and freight
CIL	Coal India Limited
CIS	Commonwealth of Independent States
CIWTC	Central Inland Water Transport Corporation Limited
CMPDIL	Central Mine Planning and Design Institute Limited
CONCOR	Container Corporation of India Limited
CPCB	Central Pollution Control Board
CPI	Consumer Price Index
CPRI	Central Power Research Institute
CRL	Cochin Refineries Limited
CTU	Central Transmission Undertaking
CVD	countervailing duty
C-WET	Centre for Wind Energy Technology
CZA	Central Zone Authority
DAE	Department of Atomic Energy
DAP	draught animal power
DESU	Delhi Electricity Supply Undertaking
DGCA	Directorate General of Civil Aviation
DGH	Directorate General of Hydrocarbons
DGM	Director of Geology and Mining
DPRs	detailed project reports
EAFs	electric arc furnaces
EAP	Environment Action Programme
EC	European Community
ECL	Eastern Coalfields Limited
EDSG	Energy Demand Screening Group
EIL	Engineers India Limited
EMC	Energy Management Centre
EMTA	Eastern Mining and Trading Association
EOUs	export-oriented units
FCCC	Framework Convention on Climate Change
FO	fuel oil
FOB	free on board
FSI	Forests Survey of India
GAIL	Gas Authority of India Limited
GAP	Ganga Action Plan
GCV	gross calorific value

GDI	gross domestic investment
GDP	gross domestic product
GDS	gross domestic saving
GEF	Global Environment Facility
GEMS	Global Environment Monitoring Systems
GHGs	greenhouse gases
GoI	Government of India
GRT	gross registered tonnage
GWP	global warming potential
HBJ	Hazira–Bijapur–Jagdishpur
HINDALCO	Hindustan Aluminium Company Limited
HPCL	Hindustan Petroleum Corporation Limited
HSD	high speed diesel
HVDC	high voltage direct current
IAAI	International Airports Authority of India
IBP	Indo-Burma Petroleum Company Limited
ICAR	Indian Council of Agricultural Research
ICD	Inland Container Depot
ICFRE	Indian Council of Forestry Research and Education
ICICI	Industrial Credit & Investment Corporation of India
ICMR	Indian Council of Medical Research
IDBI	Industrial Development Bank of India
IFCI	Industrial Finance Corporation of India
IGCC	integrated gasification combined cycle
IIP	Index of Industrial Production
IISCO	Indian Iron and Steel Company Limited
INDAL	Indian Aluminium Company Limited
IOC	Indian Oil Corporation
IPCC	Intergovernmental Panel on Climate Change
IPFIs	Indian public financial institutions
IPM	integrated pest management
IPPs	independent power producers
IREDA	Indian Renewable Energy Development Agency
IREP	Integrated Rural Energy Planning
ISPs	integrated steel plants
IWT	Inland Water Transport
JFM	joint forest management
JKML	Jammu and Kashmir Minerals Limited
JNPT	Jawaharlal Nehru Port Trust
JNU	Jawaharlal Nehru University
JVCs	joint venture companies
LDO	light diesel oil
LNG	liquefied natural gas
LOLP	loss of load probability
LPG	liquefied petroleum gas
LSHS	low sulphur heavy stock

MALCO	Madras Aluminium Company Limited
MCL	Mahanadi Coalfields Limited
MCM	million cubic metre
MECL	Mineral Exploration Corporation Limited
MEDEE-S	Modeled evolution de la demande energie
MINARS	Monitoring Indian National Aquatic Resource Systems
MINAS	minimum national standards
MISH	market information surveys of households
MNES	Ministry of Non-conventional Energy Sources
MoC	Ministry of Coal
MoCA	Ministry of Civil Aviation
MODVAT	Modified Value Added Tax
MoEF	Ministry of Environment and Forest
MoF	Ministry of Finance
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoR	Ministry of Railways
MoRD	Ministry of Rural Development
MoST	Ministry of Surface Transport
MoUAE	Ministry of Urban Affairs and Employment
MPCE	monthly per capita expenditure
MRL	Mangalore Refinery Limited
MRPL	Mangalore Refinery and Petrochemicals Limited
MRTP	Monopolies and Restrictive Trade Practices
MS	motor spirit
MSDC	Maritime States Development Council
MSW	municipal solid waste
MTOE	million tonnes of oil equivalent
MTOs	multimodal transport operators
MTPA	million tonnes per annum
MUs	million units
NAAI	National Airports Authority of India
NAAQS	National Ambient Air Quality Standards
NAEB	National Afforestation and Eco-development Board
NALCO	National Aluminium Company Limited
NCAER	National Council of Applied Economic Research
NCL	Northern Coalfields Limited
NCR	National Capital Region
NEC	North-Eastern Coalfields
NEEPCO	North-Eastern Electric Power Corporation
NELP	New Exploration Licensing Policy
NGO	non-governmental organization
NHAI	National Highways Authority of India
NHPC	National Hydroelectric Power Corporation
NIP	New Industrial Policy
NLCL	Neyveli Lignite Corporation Limited
NOCs	national oil companies

NPL	National Physical Laboratory
NPTI	National Power Training Institute
NRSE	New and Renewable Sources of Energy
NSSO	National Sample Survey Organisation
NTFPs	non-timber forest products
NTPC	National Thermal Power Corporation
NTPC	National Transport Policy Committee
OCC	Oil Coordination Committee
ODP	ozone-depleting potential
ODS	ozone depleting substances
OECD	Organization for Economic Cooperation and Development
OGL	Open General License
OIL	Oil India Limited
OMS	output per man-shift
ONGC	Oil and Natural Gas Corporation
OPEC	Organization of Petroleum Exporting Countries
OVL	ONGC Videsh Limited
OYW	own-your-wagon
Pax	passenger
PCF	peaking capability factor
PDS	public distribution system
PED	Power and Energy Division
PFC	Power Finance Corporation
PFM	participatory forest management
PLF	plant load factor
POL	petroleum, oil and lubricants
PPBV	parts per billion volume
PPMV	parts per million volume
PPP	purchasing power parity
PPTV	parts per trillion volume
PSC	production-sharing contract
PSU	public sector undertaking
PTC	Power Trading Corporation
PV	photovoltaic
R/P	reserve–production
REC	Rural Electrification Corporation
REDB	Rural Energy Database
RETs	renewable energy technologies
RFC	recorded forest cover
RoR	rate of return

RPL	Reliance Petroleum Limited
RSPCL	Rajasthan State Power Corporation Limited
SAIL	Steel Authority of India Limited
SBSTA	Subsidiary Body on Scientific and Technological Advice
SCCL	Singareni Collieries Company Limited
SCI	Shipping Corporation of India
SEB	State Electricity Board
SECL	South Eastern Coalfields Limited
SEDI	Sectoral Energy Demand for India
SERC	State Electricity Regulatory Commission
SEC	Solar Energy Centre
SHP	small hydro power
SIG	Standing Independent Group
SKO	superior kerosene oil
SPM	suspended particulate matter
SPV	solar photovoltaic
SRTUs	state road transport undertakings
STU	State Transmission Undertaking
T&D	transmission and distribution
TEESE	TERI Energy Economy Simulation and Evaluation Model
TERI	Tata Energy Research Institute
TEUs	twenty-feet equivalent units
THDC	Tehri Hydro Development Corporation
TISCO	Tata Iron and Steel Company Limited
TOE	tonnes of oil equivalent
TPPs	thermal power plants
TQM	total quality management
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USPHS	United States Public Health Service
WCL	Western Coalfields Limited
WHO	World Health Organization
WIMCO	Western India Matches Company
WRI	World Resources Institute
ZSI	Zoological Survey of India

Regulatory reforms in the Indian energy sector

Since the initiation of economic reforms in India in 1991 there has been a growing acceptance of the need for deepening these reforms in several sectors of the economy which were essentially in the hands of the government for several decades. It is also now realized that if substance has to be provided to macroeconomic policy reform then it must be based on reforms that concern the functioning of several critical sectors of the economy, among which the infrastructure sectors in general and the energy sector in particular are paramount. The inadequate response of the private sector in investing in the energy sector over the last seven to eight years has led to the widespread recognition of the need for reforms by the government and the public at large.

It is now realized that even though major companies and financial organizations throughout the world are interested in investing in India's energy sector, they perceive the absence of regulatory changes and reforms in the energy sector as a major barrier to making large-scale investments that substantially increase India's capacity to fuel its economy. Indeed, it is also realized that if these reforms do not take place then there would be a consequent shortage in investments in the energy sector, which, in turn, could considerably hold up economic growth. In fact, it is fortunate that a combination of factors including, for instance, improvements in capacity utilization in the power plants and the recent downturn in economic activity did not place heavier pressures on the supply of energy than that was necessary to sustain a reasonable level of economic growth. As a result, the Indian economy has been able to grow without the substantial increase in physical shortages of energy supply that were expected earlier.

This edition of TEDDY (TERI Energy Data Directory & Yearbook) addresses the issue of regulatory reforms in the Indian energy sector since the subject is of considerable importance and contemporary interest in the context of economic reforms in general and economic growth in the country. A discussion on regulatory reforms in the energy sector needs to be seen in the specific context of the different elements of the sector. For instance, the traditions, experience, and structure of the hydrocarbons industry in India require a certain set of institutional reforms that are not necessarily relevant to the coal industry, which for historical and other reasons had pursued a very different path of development and growth. Accordingly, in this chapter, reforms will be dealt with in keeping with the form of energy and source of supply that exists in the Indian energy sector.

Coal

The coal industry needs an urgent set of reforms because expansion of further capacity is critically dependent on funding from outside the government. Also, there is need to improve the functioning of the industry as a whole, which unfortunately has been neglected by policy makers for a considerable period of time. The coal industry in India has a long history. However, in recent years, despite significant expansion and major investments largely from government sources, little analysis has been carried out of the steps that need to be taken for critical reforms.

The rationale for rapid expansion of coal mining and production arises from a number of factors. Firstly, coal is the major fossil fuel resource available in India, and despite problems in the entire coal chain, it has provided a major portion of energy supplies for power generation, particularly in the past two decades. Coal is the cheapest fuel option for power generation in most regions of the country. Hence, increase in coal supply is essential for the expansion of power generation to meet the demand from an expanding economy in the country. Secondly, the growing dependence on oil imports places India in a difficult situation with respect to energy security. An additional reason for the expansion of coal supply is the major employment potential this industry has in a region that is generally poorer than the rest of the country. Clearly, employment cannot be a major factor for stimulating growth of the coal industry, but it certainly is a significant reason for ensuring that in a labour-surplus economy, coal production and supply receives greater importance than other energy forms that entail capital-intensive production.

It is on the basis of these considerations that the government has recognized the need for new coal policy initiatives and for rationalization of the legal and regulatory framework that would govern the future development of this industry. The major initiatives taken thus far by the government are as follows.

1 Creating conditions whereby the public sector undertakings, which constitute the major share of the coal supply industry, function in a commercially dynamic environment and are provided freedom of action without constraints due to excessive government controls and regulation.
2 Creating conditions whereby the private sector can participate in the extraction and marketing of coal. While the response thus far has not been up to expectations, there is now growing interest on the part of the private sector both in India and overseas to involve itself in the whole chain of coal industry operations. Needless to say, there are still a number of hurdles and barriers which have not allowed private sector participation to grow in the desired manner, but it is expected that with the exercises currently under way, there would be a significant improvement in the involvement of the private sector in this industry.
3 The government has also taken in hand the restructuring of the legal and regulatory framework governing operations in the coal industry so that a more investor-friendly framework is put in place for attracting private sector investments in the sector.

The ultimate objective of some of the ongoing measures and others under consideration is to see that a competitive environment is created for the functioning of various entities in this industry. This would not only bring about gains in efficiency but also effect cost reduction, which would consequently ensure supply of coal on a larger scale at lower prices. Competition would also have the desirable effect of bringing in new technology, for which there is an urgent and overdue need since the coal industry has suffered a prolonged period of stagnation in technological innovation.

In 1993, the Ministry of Coal formulated a new policy with the objective of mobilizing additional financial resources for bridging the demand and supply gap. The Coal Mines Nationalization Act, 1973 was accordingly amended to provide for a legal framework facilitating investments from major user industries that would have a direct stake in enhanced supply of coal. Unfortunately, the response thus far has not been very encouraging. There are several reasons for this, which cannot be covered in a publication of this kind. However, there is a perception that the private sector is not being provided with a level playing field as against public sector enterprise. There are also criticisms on a lack of transparency in the legal and regulatory framework in the sector and a lack of clear definition of institutional responsibilities involved in decision-making in this sector. There are also problems of coordination between different central and state government departments in respect of allowing and facilitating investments by the private sector. The government departments have an important responsibility in terms of providing land, ensuring access to the coal mines and right of way, etc. so that quick decision-making and private investments take place without too much delay in the preliminary arrangements required for coal-mining activities. There is also some lack of clarity on the relative roles of the central and state governments, particularly in the issuance and administration of coal exploration and exploitation rights.

There are difficulties in the mine approval process too. The process of environmental clearance, which ultimately has to be provided by the Ministry of Environment and Forests, has proved to be a major detriment to quick decision-making. Barriers are also seen in the cost-effective implementation of laws such as the Contract Labour (Regulation and Abolition) Act, 1970. The system of coal linkages and the necessity for major producers to be linked with major consumers cause delays and introduce avoidable complexities. This hampers the development of a free and competitive market environment. As a result, potential private sector investors have to waste a great deal of time and effort in arriving at linkages – a system that is hardly seen in any other part of the world.

The government introduced a process of price liberalization in March 1996 with the intent of fully liberalizing coal pricing by January 2000. This certainly would make a major difference in providing the level playing field that private sector investors have been pointing to as a missing element in the current situation. Nevertheless, issues related to the determination of royalty and the regulation of monopoly pricing would have to be reviewed, requiring a proper regulatory body to be established to ensure that the interests of producers and consumers alike are protected through the curbing of possible monopoly power. It is also vitally important for the regulatory regime to be established to conform to international practices and procedures. This is essential so that a potential private investor finds it more remunerative, taking into account the risks and other relevant factors, to invest in India than in some other country.

The Ministry of Coal is currently engaged in a major exercise to come up with a regulatory arrangement that would serve the interests of the country and the coal industry in expansion of capacity, achievement of higher efficiency, and other reforms that would in general improve the health of the coal industry. The consultants to this exercise are the International Mining Consultants of the UK and TERI in India. It is expected that the government would act on the recommendations of this team of consultants and introduce legislation where necessary for bringing about major reforms in the regulatory structures and processes that currently define the functioning of the coal industry in India.

Oil

The oil industry in India is a relatively efficient and well-organized industry, particularly in respect of downstream operations. The is because most of the public sector companies operating at the downstream end have drawn heavily in terms of personnel and practices from established international oil companies. Also, given the fact that oil pricing has generally allowed these companies to earn reasonable returns, they have been able to invest in improvements and upgradation of equipment and technologies and, in general, maintain a level of efficiency in their operations, which have provided a healthy base to the industry's evolution and development. With the Government of India's move towards dismantling the APM (administered pricing mechanism), on the basis of which prices of oil products are set currently, there is a need to think through and implement early a post-APM structure for regulation of this industry.

To understand what needs to be done beyond the dismantling of the APM, one needs to go back in time to see how the APM actually came into existence in a market which was relatively free and generally competitive. With the quadrupling of oil prices in 1973/74, India had the difficult task of regulating oil product prices consistent with the increase that had taken place in the global oil market while also protecting the economy from sudden shock, and the APM was introduced to help the government decide on oil product prices. Had system been done away with in the late 1980s when oil prices reached much lower levels than previously, the industry would have had a much higher level of competition than is currently seen. The APM has imposed certain constraints and has resulted in several distortions in the pattern of consumption of oil products. This makes the transition to a post-APM regime more difficult than would have been the case if APM had been dismantled earlier.

This is not to say that a regulatory regime that comes into existence now would merely pass on the changes in price that take place in the international oil market to the consumers in India. In fact, the regulatory body would have to consider various social, environmental, and other externalities when prices are established for implementation by the oil industry. It also needs to be kept in mind that the price of kerosene, which is heavily subsidized, cannot be increased in one single action. Some method has to be envisaged by which transition takes place in a manner painless for the consumer, but at the same time fair and efficient from the point of view of the producer. For instance, issues of oil security will become a dominant concern in oil product pricing in the future, particularly since India's imports of petroleum and petroleum products have been growing substantially in the past few years, and future projections indicate, as shown in other pages of TEDDY, that the dependence would increase to an almost unhealthy level.

Also relevant is the whole mix of environmental impacts that oil production, distribution, and consumption have on society. Hence, there is a need for taking into account the economic implications of environmental pollution and internalizing the cost thus estimated within the price of oil products. The oil industry has been through a difficult period in the recent past, particularly during the years when oil product prices were not increased and the industry ran a huge deficit in the oil pool account. In periods of such financial strain, the industry goes through a stage of stagnant development and slow pace of innovation and efficiency improvements. Thus, investment decisions taken would not be optimal in terms of efficiency because they would not reflect the dynamics of the open market. The deficits in the oil pool account had implications for macroeconomic policy in the country also, largely because the oil industry has been seen in the past as a major source for appropriating revenues to help the government reduce its fiscal deficit.

India's oil markets are growing rapidly, particularly since the oil–GDP elasticity is generally higher than unity. Large investment would, therefore, be required to meet the burgeoning demand for oil products. Indeed, this is an area which is beyond the scope of the public sector because the level of investments required is much higher than that which lies within the ability of the public sector companies to meet through generation of internal surpluses.

In principle, the objectives of regulatory reform in the oil industry are largely similar to those in the coal industry. However, there are significant differences in the actions that would be required in the case of this particular industry. To initiate the process of reform, the Government of India appointed a group, popularly known as the 'R' Group, which consisted of experts, oil industry professionals, government officials, and a select group of private sector leaders. The report of this group was submitted in 1996 and its major recommendations included the dismantling of the APM and the institution of tariff reforms. Based on an internal exercise carried out by the Ministry of Petroleum and Natural Gas on the report of the R Group, a notification was issued by the Government of India in November 1997 announcing the phase-out of the APM between April 1998 and 2002. At the same time, reforms were also initiated upstream with the Government of India liberalizing the terms of offer of exploration blocks by unveiling the NELP (New Exploration Licensing Policy). As part of this policy, 48 separate blocks, including 38 offshore blocks, have been offered to the public and the private sector companies interested in entering these areas for exploration and production of hydrocarbons. Apart from the generally favourable terms offered by the government to bidders as part of the current policy, the NELP also provides national oil companies and private sector parties with a level playing field – all parties would have to bid for the blocks that have been offered and the choice of the successful bidders would be purely on the basis of the merit of the bid itself.

The legal framework for regulation of exploration and production of oil and gas is enshrined in the Oil Fields Development & Regulation Act, and the Petroleum and Natural Gas Rules. These provide power to the government for granting licences for exploration and production, for charging royalty, etc. The Act was amended recently to enable the government to introduce the NELP. Terms offered under the NELP are liberal and positive for the private sector operators interested in participating in exploration and production in India. At the same time, the government is considering the conversion of the DGH (Directorate General of Hydrocarbons) into a statutory body. This would be essential for combining regulatory and promotional decisions involving the private sector, so that all problems related to the private sector entering into exploration and production can be dealt with by a single office in the Government of India. The DGH was actually set up consequent to a recommendation by the P K Kaul Committee for looking into the operations of the ONGC (Oil and Natural Gas Corporation) Limited. The DGH was expected to ensure that the exploitation of oil fields and reserves in the country would be done in a manner that does not lead to any waste or loss of reserves. This was the direct response to the findings that on account of faulty decision-making by some authorities, some of the reserves in the Bombay High region were lost as a result of excessive flogging of the oil fields concerned. However, once the DGH was set up, its role was expanded beyond what had been envisaged in the P K Kaul Committee, and it has become the single point of reference for all issues related to the involvement of the private sector in decisions for exploration and production of hydrocarbons. Some assessment of the current functioning of the DGH and careful restructuring are now justified.

Substantial changes are required in the regulation of the refining and marketing ends of the hydrocarbons industry as well. The removal of controls, particularly for purchase of crude oil, would lead to free sourcing of crude oil, independent determination of the slate of crude to be purchased, as well as the product mix produced by the refineries, and the removal of marketing and distribution controls. All these measures are expected to lead to an improvement in the efficiency of the downstream end of the hydrocarbons industry. Nevertheless, given the current state of downstream operations of the hydrocarbons industry, the role of the regulator would necessarily be limited. There would, nevertheless, continue to be a justification for some subsidization of supply of oil products, particularly in far-flung areas. Some systems, whereby energy security is ensured by maintaining adequate levels of stocks of crude and oil products, would also need special attention, along with several other issues that would directly impact on the prices of products allowed in the market. For instance, an oil company would have no incentive for adequate stocking to meet the country's overall energy security needs if the cost of such stockholding was not allowed as part of the cost and prices of products provided in the market. Hence, the regulatory body would need to lay down certain rules by which the oil companies would operate and ensure that the costs in meeting those rules are included with due care and careful estimation of their magnitude. Essentially, therefore, the role of the regulator would evolve over a period of time and it is expected to change from one of merely accounting costs and determining price on simple principles to one that requires some sophistication of analysis and understanding of the broad impacts of oil consumption in the country so that overall social objectives and national interests are served appropriately.

Natural gas

The government has been the sole authority for fixing the price of natural gas in the country. It has also been taking decisions on the allocation of gas to various competing consumers. In keeping with the decision to decontrol the natural gas industry, the government commissioned the study on the options available to it for regulation and decontrol. This study was conducted by the National Economic Research Associates of the UK, and its major recommendations have been considered by the government in consultation with industry. It is expected that legislation will be introduced to establish an independent regulator for the natural gas industry. Of late, however, there has been some reconsideration of this decision and some sections of the government are tending to favour the establishment of a single regulator who is responsible both for prices of petroleum products and natural gas, for different end-uses. This is because natural gas is a substitute for several petroleum products and pricing decisions will have to be consistent to ensure that the right mix of energy sources is used in the economy and also that, both in terms of the response of suppliers and the decisions by consumers, prices are set in a manner that leads to a desirable outcome and does not result in any distortions and surpluses and shortages of one or the other fuel. The difference between natural gas and petroleum products lies in the fact than in that the transportation of natural gas through pipelines has substantial economies of scale. The exploitation of these economies of scale requires regulatory decisions in the market different from those for petroleum products. In other words, if transportation economies have to be fully exploited, then a certain magnitude of transportation of gas by pipeline would have to be ensured to achieve these economies of scale. Hence, the regulatory body established for the purpose would have to ensure that demand centres are developed in a manner that allows the consumer the benefits of economies of scale in pipeline transportation.

Power

Power sector reforms were initiated by the Government of India with the liberalization process set in motion in 1991. The first decision that was taken was to allow private investments for power generation. The initial response to the statement of policy on this change was extremely enthusiastic, with a large number of companies both in India and overseas showing interest to investing in power generation. The government saw the importance of rapid increases in power generation capacity to meet the demands of a rapidly growing economy and to plug the gaps that existed in physical supply at that point of time. However, at that stage, the actual mechanics of how the private sector could be attracted were not clearly spelled out. There was an inflated expectation that with India announcing a policy shift, there would be so much capital flowing into the country's power sector that the challenge would be one of stemming the tide rather than inducing it. This, in retrospect and in the opinion of several analysts even at that time, proved unrealistic.

The basic problem in power sector reforms arose from the fact that the state electricity boards are essentially bankrupt and cannot be seen as reliable entities for business, with little or no assurance of payments to any supplier that provides them with either electricity or other goods and services. It is also now evident that starting with investments in power generation without considering privatization of distribution was a beginning made at the wrong end.

Reforms also did not take place in the regulation of the industry. With most electricity boards pricing power for certain groups of consumers, such as agricultural consumers and some high-tension industries, with varying levels of subsidies, their financial health and accountability remained seriously eroded. It is only with the passage of the Central Electricity Regulatory Commission Act in 1998, that regulatory reforms have been initiated, and both the central and the state regulatory commissions are now functioning with growing effectiveness and larger geographical coverage. Over a period of time, this would help to rationalize electricity operations and ensure efficiency gains that, for instance, can be expected based on the experience of the UK model of electricity regulation.

The most important challenge facing the electricity supply industry is to be seen in two parts, which are basically interrelated. Firstly, the regulatory structures and systems have to function effectively, and for this considerable training and learning is required for all the stakeholders involved, namely regulators, consumers, the regulated utilities, and others. Secondly, to introduce privatization of the distribution of power, governments will have to show originality and political will so that concerns often voiced by labour unions and employees do not halt the progress of privatization of distribution. Essentially, this would require careful understanding of all implications involving labour and then devising packages that are mutually acceptable to the management and labour. It is not expected that radical changes would take place in the industry in a short period of time, but at the same time it would be incorrect to assume that merely setting up regulatory bodies would bring about the change required. A much higher level of expertise would have to be brought to bear on developments in this sector if progress is to be achieved. This should also be accompanied by a clear strategization of other steps to be taken in bringing about a higher level of competition in the industry.

Organization of the energy sector

The legislative framework

India is a union of 26 states. Consequently, the legislative authority under Article 246 of the Constitution of India is split into union and states with concurrent jurisdiction over some subjects. Recently, vide the 73rd and 74th amendments in 1991, the devolution of authority, in selected subjects, including those related to energy, has been recommended by the states to the village-level panchayats and urban municipalities. States like Madhya Pradesh have given effect to such devolution to bodies of local self-government. The Seventh Schedule of the Constitution of India provides the list of subjects reserved for the Union. As regards energy, the subjects are given below.

- Atomic energy and mineral resources necessary for its production
- Regulation and development of oil fields and mineral oil resources, and petroleum and petroleum products
- Regulation of mines and mineral development as declared by the Parliament
- Regulation of labour and safety in mines and oil fields
- Regulation and development of inter-state rivers.

The concurrent list mentions only one energy-related subject, i.e., electricity. This skewed distribution of legislative powers explains the dominant role of the Union Government in the energy sector. In general, the states have no role in the regulation, promotion or conservation of atomic-, petroleum- or coal-based energy sources; these continue to be the preserves of the Union Government. The states' main involvement has been in the electricity sector and more recently in the promotion of NRSE (new and renewable sources of energy).

Organization of the Union Government and related agencies in the energy sector

The organizational framework of the Union Government and related agencies in the energy sector is depicted in Figure 1. Under the Government of India, there are a multitude of ministries and organizations vested with disparate functions concerning sustainable energy development. However, the forums and structures for coordinated action amongst all these separate authority centres are not well defined. Nevertheless, three forums for coordinated planning and thinking for energy development have been clearly identified. First, the Parliament and its committees provide a ready forum particularly with regard to the budgetary allocation for energy development and review of the government's policy in this area. Second, the cabinet and its committees are a useful and appropriate forum for collective and consensual planning and decision-making. Third, the Planning Commission, which develops and reviews investment programmes for all the sectors, provides a forum for micro-consideration of policy implications and investment needs.

Department of Atomic Energy

The Department of Atomic Energy is entrusted with the responsibility of designing, erecting, commissioning, and operating nuclear power plants. It has under its wing three units, namely, the Bhabha Atomic Research Centre at Mumbai, and two atomic research centres at Tarapur and Kalapakkam.

Ministry of Power

The MoP (Ministry of Power) is concerned with perspective planning, policy formulation, processing investment needs of public sector projects,

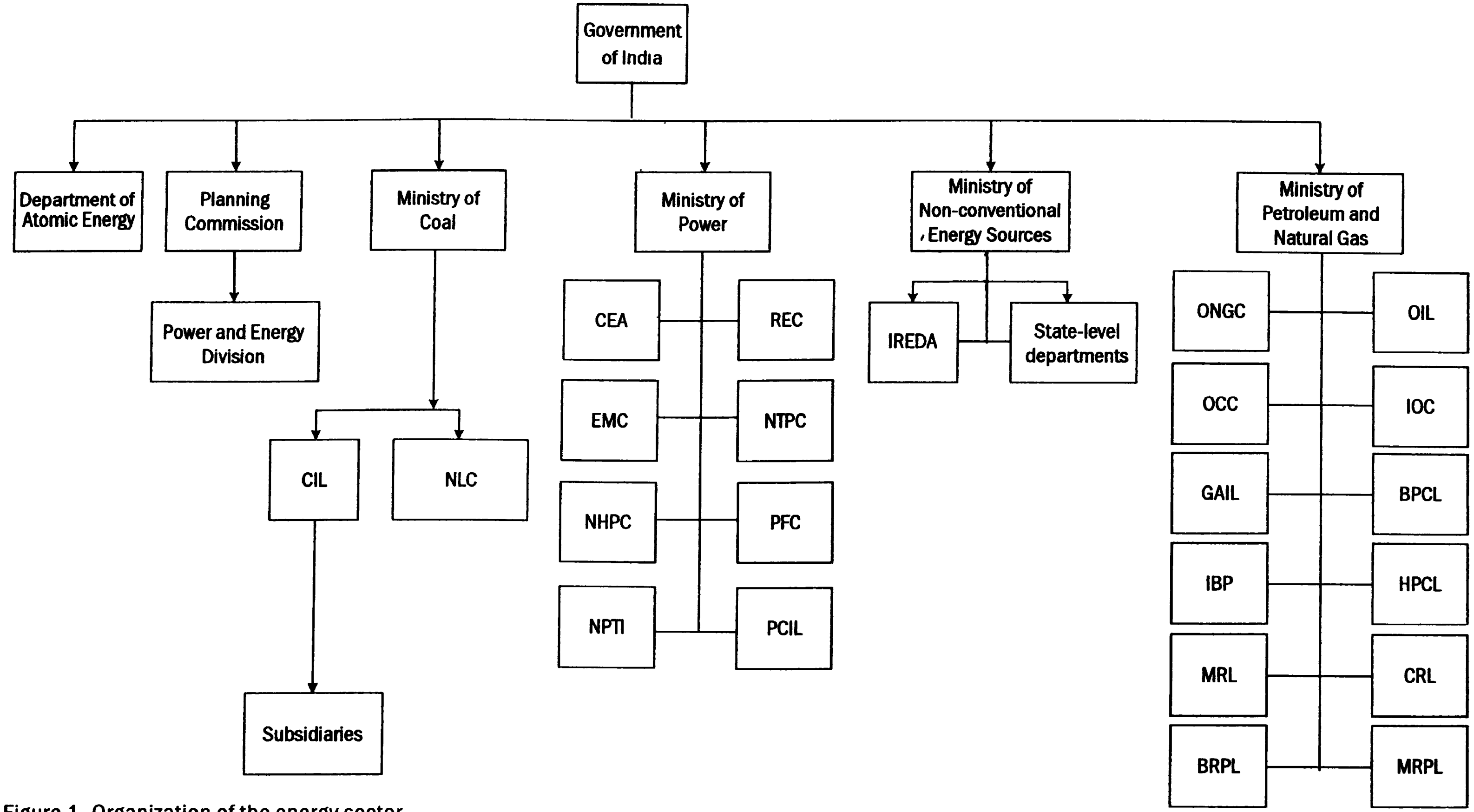


Figure 1 Organization of the energy sector

BPCL: Bharat Petroleum Corporation Ltd; BRPL: Bongaigaon Refinery and Petrochemicals Ltd; CEA: Central Electricity Authority; CIL: Coal India Limited; CRL: Cochin Refineries Ltd; DAE: Department of Atomic Energy; EMC: Energy Management Centre; GAIL: Gas Authority of India Ltd; GoI: Government of India; HPCL: Hindustan Petroleum Corporation Ltd; IOC: Indian Oil Corporation Ltd; IREDA: Indian Renewable Energy Development Agency; IBP: Indo-Burma Petroleum Company Ltd; MRL: Madras Refineries Ltd; MRPL: Mangalore Refinery and Petrochemicals Ltd; MNES: Ministry of Non-conventional Energy Sources; NHPC: National Hydro-electric Power Corporation; NTPC: National Thermal Power Corporation; OCC: Oil Coordination Committee; OIL: Oil India Limited; ONGC: Oil and Natural Gas Corporation; PCIL: Powergrid Corporation of India Ltd; PFC: Power Finance Corporation onitoring of the implementation of power ojects, training and manpower development, and lministration and enactment of legislation with gard to thermal and hydel power generation and ansmission and distribution. The MoP adminis- rs the Indian Electricity Act (1910), the Elec- icity (Supply) Act (1948), and the Electricity egulatory Commission Act (1998). It also under- kes such amendments to these acts as may be nec- ssary from time to time, in conformity with the overnment's policy objectives. The MoP started nctioning independently with effect from 2 July 992. Earlier, it was known as the Ministry of En- gy, comprising the departments of power, coal, nd non-conventional energy sources.

Listed below are agencies that assist the Minis- y in executing its policies and programmes.

The CEA (Central Electricity Authority), con- ituted under the Electricity (Supply) Act (1948), dvises the ministry on technical, financial, and conomic matters.

The REC (Rural Electrification Corporation) pro- des financial assistance for rural electrification pro- rammes.

The National Hydroelectric Power Corporation lans, promotes, and integrates the development f hydroelectric, tidal, and wind power in the coun- y.

The NTPC (National Thermal Power Corpora- on) is the premier thermal power generator of the ountry with around 20% of the total generation apacity.

The Badarpur Management Contract Cell helps dminister the Badarpur Thermal Power Station anagement contract between the Government of dia and the NTPC.

The PFC (Power Finance Corporation) as incorporated in 1986 with the objective of obilizing capital from non-budgetary sources for roviding term finance for power generation rojects.

The Tehri Hydro Development Corporation was corporated in July 1988 to plan, promote, or- anize, execute, operate, and maintain hydropower rojects in Uttar Pradesh.

The Powergrid Corporation of India Limited, in- orporated in 1989, is the main provider of extra high- oltage and high-voltage transmission network in the ountry. It is responsible for all the existing and fu- ure transmission projects in the central sector and lso for the formation of the National Power Grid.

The Energy Management Centre, established in 1989, is an executive agency under the Energy Conservation Cell in the MoP. It formulates policies, designs energy management programmes, and ensures effective coordination. Its main aim is to improve energy efficiency in the country.

The CERC (Central Electricity Regulatory Commission) was set up on 25 July 1998 under the Electricity Regulatory Commission Act (1998) as an independent statutory body with quasi-judicial powers. The CERC regulates tariff-related matters, advises the central government on the formulation of a tariff policy, frames the guidelines pertaining to tariff and promotes competition and efficiency in the electricity sector. Under the CERC, there are SERCs (state electricity regulatory commissions) to (1) rationalize the tariff structure, (2) improve the financial health of their respective SEBs (state electricity boards), and (3) avail the interest subsidy on loans and other incentives from the PFC.

The CPRI (Central Power Research Institute) was set up to serve as a national laboratory for undertaking applied research in electric power engineering. It also functions as an independent national testing and certification authority for ensuring the reliability of electrical equipment and components.

The NPTI (National Power Training Institute) has been set up under the administrative control of the MoP to train the power sector personnel in India.

Ministry of Coal

The MoC (Ministry of Coal) formulates policies and strategies for the exploration and development of coal and lignite reserves and sanctions important projects of high values. These key functions are exercised through PSUs (public sector undertakings) such as the CIL (Coal India Limited) and its subsidiaries, and the NLC (Neyveli Lignite Corporation) Limited. The CIL monitors the performance of its subsidiary companies and is involved in long-term planning, conservation, and R&D of coal mining. The subsidiary companies commission and execute new and ongoing coal-mining projects. The NLC Limited is entrusted with the task of lignite production and power generation. In addition to these, the MoC acts in close association with the SCCL (Singareni Collieries Company Limited), which is a joint venture of Andhra Pradesh and Government of India.

Ministry of Petroleum and Natural Gas

The MoPNG (Ministry of Petroleum and Natural Gas) is responsible for the exploration and production of crude oil and natural gas as well as for refining, distribution, and marketing of petroleum products and natural gas. Its role also extends to exports and imports of crude oil and petroleum products. The tasks of the MoPNG are exercised through various PSUs such as the EIL (Engineers India Limited), GAIL (Gas Authority of India Limited), and the ONGC (Oil and Natural Gas Corporation) Limited. The EIL provides engineering consultancy services for the development of petroleum, petrochemicals, ocean engineering, and other related chemical industry development programmes. GAIL was incorporated in 1984 with the primary objective of constructing the cross-country HBJ (Hazira–Bijapur–Jagdishpur) gas pipeline. GAIL has been accorded the *Navratna* status along with the ONGC Limited, the IOC (Indian Oil Corporation) Limited, the BPCL (Bharat Petroleum Corporation Limited), and the HPCL (Hindustan Petroleum Corporation Limited).

The Oil Coordination Committee coordinates various activities such as planning for imports and exports of petroleum products and crude oil. It prepares short-term estimates of supply, demand, and imports; formulates new projects; and monitors the progress of ongoing projects as well as the performance of the oil industry in general. The IOC, the HPCL, and the BPCL refine and market all the refined products of indigenous refineries as well as imported petroleum products. There are also some refineries, which only supply refined products in bulk and do not directly market their products.

Ministry of Non-conventional Energy Sources

The MNES (Ministry of Non-conventional Energy Sources) was created in 1992 as a separate entity under the Government of India, replacing the erstwhile Department of Non-conventional Energy Sources. The main responsibilities of the MNES include resource assessment, R&D, demonstration, commercialization, and large-scale utilization of NRSE such as biogas, biomass, solar energy, wind energy, small hydro power, ocean energy, geothermal energy, alternative fuels, hydrogen, and drought animal power. Other important activities of the MNES include (1) awareness creation, (2) information dissemination for the popularization of non-conventional renewable energy devices and systems, and (3) international cooperation for the financial and technical assistance from multilateral and bilateral agencies.

The programmes of the MNES are implemented through state renewable energy agencies, electricity boards, R&D institutions, industries, and non-governmental organizations. Since 1996, these programmes have been made more market-oriented, with a greater role for the private sector. IREDA (Indian Renewable Energy Development Agency), set up in 1987, has grown into an effective promotional, developmental, and financing institution and has generated greater awareness of NRSE.

Power and Energy Division of the Planning Commission

The Planning Commission is the think-tank of the Government of India. It formulates plans, frames policies, and sets targets after a careful assessment of the available resources for the growth and development of the economy. Under its wing, the PED (Power and Energy Division) is concerned with all the plan-related policies and programmes in the energy sector. This includes demand assessment, supply-side management, and conservation efforts. The PED also works on the national energy policy. The PED has three units, namely, power and energy economics, coal, and petroleum. These units are entrusted with the tasks of: (1) finalizing the Ninth Plan document in respect of the energy sector, (2) finalizing annual reports of the ministries, and (3) providing advisory support to the ministries.

Overview

Over the years, India's energy sector received a significant allocation of Plan resources: its share of the funds went up from 15% in the Third Five-Year Plan (1961–66) to nearly 29% during 1998/99. This led to a growth in the primary energy consumption at a rate of about 7.7% a year over 1987–97 (BPSR 1998). Specifically, while world's consumption of energy grew by 1% during 1997 over the previous year, it grew by 6.1% in India. Apart from commercial energy, a large amount of traditional energy sources in the form of fuelwood, agricultural waste, and animal residue are used in the country, mainly to meet the rural energy demand. Till date, traditional energy sources constitute nearly 40% of the total energy consumption in the country. However, due to lack of sufficient data, this chapter deals with only commercial energy sources.

Energy–economy interaction

Energy use is always linked with the economic activities in a country. So is the case with India. The economic reforms initiated in 1991 resulted in a higher rate of economic growth during the Eighth Five-Year Plan (1992–97). The average annual growth of GDP (gross domestic product) during the Eighth Five-Year Plan was 6.8%, as against 6% during the Seventh Plan period. The GDP growth rate has, however, showed a decline during 1997/98, which was estimated at five per cent (Figure 1), due to slow progress in the agricultural and industrial sectors. The significant growth in the economy has pushed up the energy demand during the recent years (Figure 2).

The increase in savings and investment over the years has led to diversification and expansion in the economy. Both GDS (gross domestic savings) and GDI (gross domestic investment) as a percentage of GDP have increased (Figure 3). The increase in savings has been achieved through innovative means of financing, for instance, by introducing sharp cuts in tax rates and by popularizing schemes to harness black money for productive purposes.

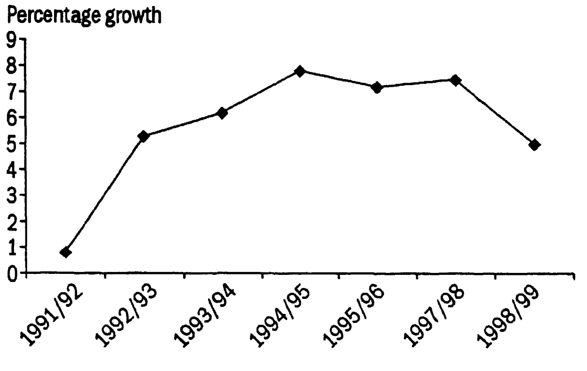


Figure 1 Rate of growth of GDP (gross domestic product) at factor cost (in 1980/81 prices)
Source MoF (1998)

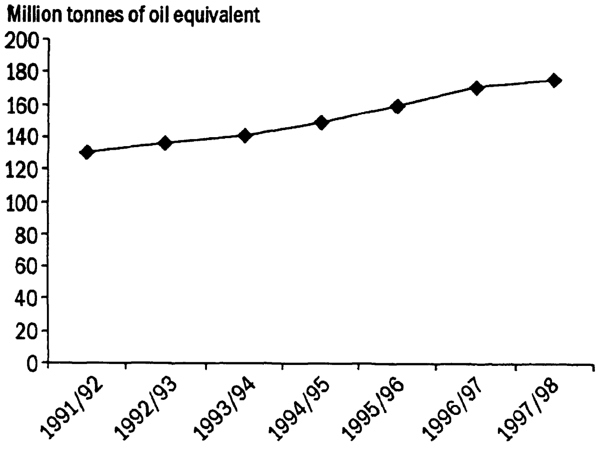
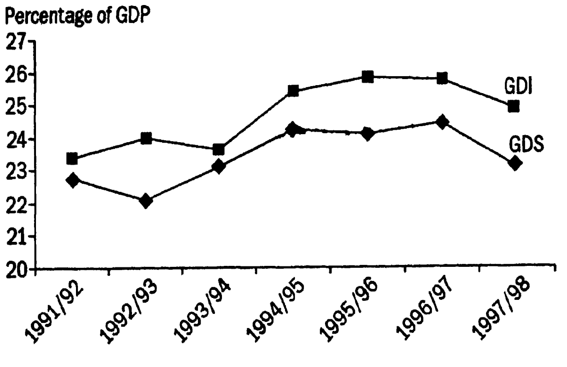


Figure 2 Commercial energy consumption



* provisional estimates

Figure 3 GDS (gross domestic saving) and GDI (gross domestic investment) as a percentage of GDP (gross domestic product) (at current prices)
Source MoF (1999)

India's economy has also undergone structural changes over the years (Table I). During 1991–98, the share of agriculture in the GDP declined from 32.8% to 28.7%, while the shares of industry and services increased by 1.4% and 2.7%, respectively.

Table I Composition of GDP (gross domestic product) (in billion rupees at 1993/94 price)

	1991/92		1997/98*	
Sector	*Sectoral GDP*	*Share (%) in total GDP*	*Sectoral GDP*	*Share (%) in total GDP*
Agriculture	2196.20	32.8	3014.36	28.7
Industry	1557.64	23.3	2594.26	24.7
Services	2936.52	43.9	4883.29	46.6
Total	6688.27	100.0	10491.91	100.0

* quick estimates
Source MoF (1999)

In addition, the other factor that drives the pace of energy demand is the growth of population, especially the increase in the proportion of urban population. During 1951–91, the Indian population grew at an annual rate of 2.15%. Further, during 1990–97, the population grew at 1.8%. It is also estimated that the population (916 million in 1995) will grow to 1394 million in the year 2025 (WRI 1995).

A noteworthy feature of the Indian demographic scenario has been the higher growth rate of urban population as against the rural. In 1997, 261 million people resided in urban areas. This figure is expected to rise to 415 million by 2015 (MoHA 1996). By 2050, it is expected that nearly 50% of the Indian population will be urban.

With the increased work-related mobility of both rural and urban population, on an average, the per capita income has risen, and was estimated at 9660 rupees (at 1993/94 prices) in 1997/98 (MoF 1999). India's per capita gross national product is, however, low when compared with the other countries; in 1997, it was 370 dollars as compared to 29 080 dollars in the US (World Bank 1999).

The cumulative effect of the above has been the rapid increase in energy consumption. During 1980–95, the consumption of energy use went up by 4.4% (World Bank 1998). Although past experience shows that availability considerations, rather than price levels, are important determinants of energy demands, the energy–GDP elasticity is often used as an indicator for studying energy consumption response. The declining trend of energy–GDP elasticity over 1953–96 (Figure 4) is due to (1) the structural changes in the economy, (2) the changing pattern of demand, and (3) the penetration of efficient and energy-saving technologies. Changes in the pattern of demand have

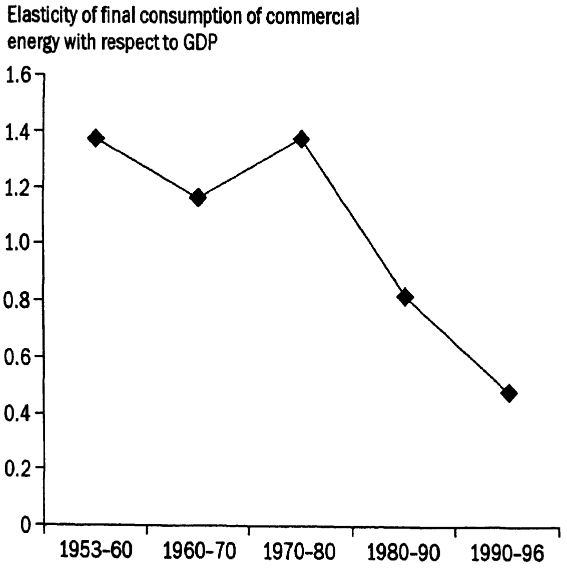


Figure 4 Elasticity of final consumption of commercial energy with respect to GDP (gross domestic product)
Source Bhattacharya and Gupta (1998)

occurred due to fuel substitution in the industry, domestic, and transport sectors. Kerosene and LPG (liquefied petroleum gas) have substituted soft coke in the household sector. In the case of railways, substitution has been from steam traction to diesel oil. Natural gas is being increasingly used as a fuel/feedstock in fertilizer, petrochemicals, power, sponge-iron industries and also in the transport sector. This elasticity is, however, very high when compared to the developed countries, reflecting India's low per capita commercial energy consumption as well as substitution of traditional fuels by commercial energy forms.

India's energy intensity (TOE [tonnes of oil equivalent] per 1000 rupees of GDP at 1980/81 price) has declined during the 1990s (Figure 5). Some of the contributing factors to this decline are (1) the growth in the economy, (2) the increasing per capita income, (3) the continuing shift from non-commercial forms of energy to commercial sources of energy, (4) the structural change in the economy, (5) the increased urbanization, (6) the shift towards thermodynamically-efficient fuels such as natural gas, and (7) the technological changes in the energy-sensitive industries.

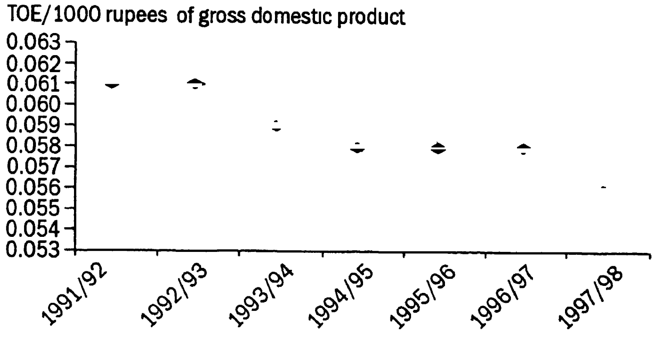


Figure 5 Trends in commercial energy intensity

Energy reserves

India is relatively well endowed with both renewable and exhaustible energy resources. Coal, oil, and natural gas are the primary commercial sources of energy. Coal is the major exhaustible resource of the country and has a life expectancy of over 212 years (Table II). While the Indian coal reserves have increased from 62.54 BT (billion tonnes) in 1991 to 69.9 BT in 1997, the world coal reserves have declined from 1040.52 BT to 1031.6 BT for the same period. However, on a per capita basis, coal resources are well below the world average. The R/P (reserve–production) ratio for natural gas is higher than that for crude oil. This clearly brings out the possibility of a higher rate of production of natural gas than at present. India's R/P ratio for crude oil has fallen from 25.6 in 1991 to 15.6 in 1997. Significant increases in oil production in the future will, therefore, depend upon its rate of accretion. To help improve the rate of reserves accretion, the following areas hold a lot of promise: (1) reprioriti-zation of exploratory efforts, (2) greater application of close-grid seismic surveys, (3) interpretation of data on priority in areas with relatively higher potential for extension/new discoveries, and (4) revaluation/re-exploration through application of technologically advanced exploration techniques.

Out of India's uranium resources of 34 000 tonnes, only 44% of it is economically exploitable. Total lignite reserves have been estimated at around 28 000 million tonnes in 1997/98. Further, the Central Electricity Authority has assessed a large hydro potential in the country to the tune of 84 000 MW, at a plant load factor of 60%. In India, the renewable energy sources are also expected to play an important role in solving the energy problems in decentralized locations and in some remote inaccessible areas where the extension of the grid system may be comparatively uneconomical. The total potential of small hydro (up to 15 MW capacity)

Table II Proven reserves of fossil fuels and R/P (reserve-production) ratio

	End 1991				*End 1997*			
	Reserves		*R/P ratio*		*Reserves*		*R/P ratio*	
Fuel	*India*	*World*	*India*	*World*	*India*	*World*	*India*	*World*
Coal (billion tonnes)	62.54	1040.52	195.00	239.00	69.90	1031.60	212.00	219.00
Crude oil (billion tonnes)	0.80	135.40	25.60	43.40	0.60	140.90	15.60	40.90
Natural gas (trillion cubic metres)	0.70	124.00	48.80	58.70	0.49	144.80	22.90	64.01

Source BPSR (1998)

and wind energy in the country is estimated at 10 000 MW and 65 578 MW, respectively.

Energy supply

The pattern of energy supplies has also changed significantly. The share of commercial fuels in the total energy supplies increased from 26% in 1950/51 to about 68% in 1996/97. The overall supply of commercial fuels (from indigenous sources and through import) has grown from 192.20 MTOE (million tonnes of oil equivalent) in 1991/92 to 245.47 MTOE in 1997/98, with an average annual growth rate of 3.2%. In this regard, Table III represents the fuelwise break-up of primary energy supply in the economy in 1991/92 and 1997/98.

Coal being cheaper and abundantly available dominates the total energy supply. Its increase in supply over the years is due to the increase in opencast mining and the application of new mining techniques. However, the average quality of mined coal has deteriorated. As regards petroleum products, the supply has increased from 54.30 MTOE in 1991/92 to 65.17 MTOE in 1997/98. Natural gas is a new entrant in the Indian energy scene and its share has increased from 16 MTOE in 1991/92 to 22.63 MTOE in 1997/98.

India continues to be a net importer of energy. In 1997/98, nearly 22% of the energy supply was through import in the form of coking coal, crude oil, and petroleum products. Increasing dependence on oil import has become a serious cause of concern. India's self-sufficiency in petroleum products has declined from 60% in 1985/86 to 34% during 1997/98. This also implies a growth in imports from 2 million tonnes to 17 million tonnes during this period. The oil import bill has increased substantially during the past two decades. It stood at 305 380 million rupees in 1997/98, which constituted about 24% of the export earnings during the period.

Energy consumption

In India, energy consumption reflects the energy demand to the extent that it is constrained by supply shortages. India's final commercial energy consumption increased from 130.7 MTOE in 1991/92 to 176.08 MTOE in 1997/98. The per capita commercial energy consumption has also increased from 152.7 kgOE (kilograms of oil equivalent) to 184.7 kgOE over the same period (Figure 6). This is due to urbanization as well as the increase in commercial energy use in the industrial and transport sectors.

The sectoral energy consumption pattern shows that the industrial sector is the largest consumer of energy, followed by the transport sector (Table IV). The energy consumption in industry, although grew at about 4% a year on an average during 1991–98, registered a decline in the share in total energy consumption from 50.4% in 1991/92 to 47.8% in 1997/98. Energy consumption in the agricultural sector registered an average growth rate of nearly 7.7% a year during 1991–98.

Coal is the dominant source of fuel in the industrial sector, with a share of nearly 72.5% in the total energy consumption (Table V). Industrial sector is the largest consumer of electricity with a share of 41% in the total consumption. Transport sector is the largest consumer of petroleum products, and accounts for nearly 50% of the total consumption. The consumption of traditional fuels (includes

Table III Primary commercial energy supply in the economy

	1991/92		*1997/98*	
Energy source	*Energy supply (MTOE[1])*	*Share in total supply (%)*	*Energy supply (MTOE)*	*Share in total supply (%)*
Coal	115.30	59.99	150.54	61.33
Oil	54.30	28.25	65.17	26.55
Natural gas	16.00	8.32	22.63	9.22
Primary electricity[2]	6.60	3.44	7.13	2.90
Total	192.20	100.00	245.47	100.00

[1] million tonnes of oil equivalent

[2] hydro and nuclear power

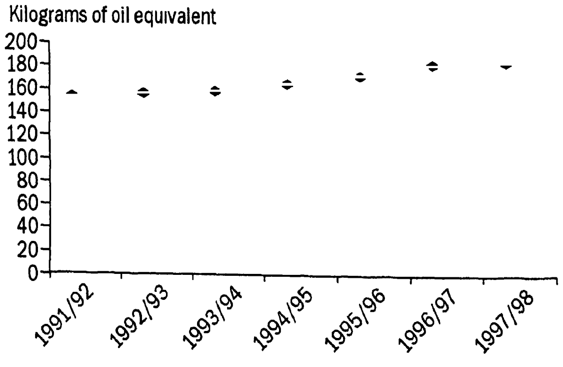


Figure 6 Per capita commercial energy consumption

Table IV Sectoral consumption of final commercial energy

Sector	*1991/92* *Energy consumption (MTOE^1)*	 *Share (%) in total consumption*	*1997/98* *Energy consumption (MTOE)*	 *Share (%) in total consumption*
Industry	65.90	50.40	84.08	47.80
Agriculture	5.60	4.28	8.75	4.96
Residential	13.10	10.02	17.21	9.77
Transport	29.30	22.41	41.55	23.60
Others	16.80	12.85	24.47	13.89
Total	130.70	100.00	176.08	100.00

[1] million tonnes of oil equivalent

Table V Sectoral consumption (million tonnes of oil equivalent) pattern of energy in 1997/98

Sector	*Coal*	*Petroleum products*	*Natural gas*	*Electricity*	*Total*
Industry	60.93	11.74	2.91	8.49	84.08
Agriculture	–	0.94	0.11	7.69	8.75
Residential	–	12.80	0.27	4.14	17.21
Transport	0.04	40.94	–	0.56	41.55
Others^1	–	13.98	6.76	3.72	24.47
Total	60.97	80 41	10.06	24.62	176.08

[1] include energy consumption for other energy and non-energy uses

fuelwood, charcoal, bagasse, and animal and vegetable waste) stood at 1285 MTOE in 1995, and witnessed an increase of 29% over 1985 (WRI 1999).

New initiatives

In order to correct various distortions in the energy sector, a series of reforms have been initiated. The recent measures in the power sector include privatization in generation and distribution of power, the enactment of the Electricity Regulatory Commissions Act (1998), the national policy on hydro power development, the mega power policy, and the introduction of transmission bill in the Parliament. In the hydrocarbon sector, steps such as the New Exploration Licensing Policy leading to the opening of exploration to foreign and private investors, opening of the refining sector to private investors, dismantling of the APM (administered pricing mechanism), and the proposal for new regulators in the upstream and downstream petroleum sector have been initiated. In the coal sector, the government has taken steps for the amendment of the Coal Mines (Nationalization) Act (1973) and a review of the regulatory framework in the coal sector.

Despite such measures, the energy sector still suffers from many infirmities. In the power sector, the peak demand shortages were about 11% during 1998/99, and the energy availability shortages stood at 5.5% (MoP 1999). Satisfactory progress is yet to take place on the demand side of energy management. Also, the private sector participation is less than expected. The coal industry is also facing many entry barriers. The deficiency in the policy intervention in the hydrocarbon sector still exists in areas such as adhering to the deregulation plan, developing alternative fuels, improving the institutional set-up, and improving the transportation network.

Future agenda

The initiatives taken so far in the energy sector have not fully conformed to the requirements of a sound integrated energy policy. Energy policy should not be formulated on a stand-alone basis. Restructuring the supply side of the industry, securing our energy future, optimum development of renewable energy supply, efficient demand-side management, energy for the rural areas, and sustainable energy–environment linkage are some of the desirable parameters required to be included in the policy.

Further, the government's decision to introduce a system of governance by independent regulation has created a new environment in the energy sector. The regulatory institutions should not only be autonomous, but also be accountable for their actions to various stakeholders. This does not mean that they are independent of the government; they are subject to the laws of land and the government's policy. It is a challenge to the policy makers for making them credible and different from the government set-up, in terms of expertise and advancing consumer interests. At the same time, the new regulators will have to establish their credibility in the new environment. A host of other issues concerning the functioning of these regulators would require the attention of the policy makers so that participation of the stakeholders is meaningful in the regulatory process.

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Table 1

Commercial energy balance (million tonnes of oil equivalent): 1995/96

	Primary energy					*Secondary energy*													
Supply–demand and sources	*Coal*	*Oil*	*Natural gas*	*Hydro*	*Nuclear*	*Soft coke*	*Liquefied petroleum gas*	*Naphtha*	*Motor gasoline*	*Aviation turbine fuel*	*Kerosene*	*High speed diesel*	*Light diesel oil*	*Fuel oil*	*Other petroleum products*	*Total petroleum products*	*Thermal power*	*Total power*	*Total energy*
Supply																			
Production	144.90	35.17	19.12	6.11	0.67	—	—	—	—	—	—	—	—	—	—	—	—	6.79	205.97
Imports	6.13	27.34	—	—	—	—	0.77	0.02	—	0.10	5.81	13.30	—	—	1.13	21.13	—	—	54.61
Exports	0.05	—	—	—	—	—	0.02	2.65	—	—	—	0.22	—	0.02	0.70	3.60	—	—	3.65
Stock changes	11.67	3.77	—	—	—	—	0.08	–0.15	–0.23	0.15	1.58	1.09	0.05	3.02	0.36	5.93	—	—	21.37
Availability	**139.31**	**58.74**	**19.12**	—	—	—	**0.67**	**–2.48**	**0.23**	**–0.05**	**4.23**	**12.00**	**–0.05**	**–3.04**	**0.07**	**11.60**	—	—	**235.56**
Conversion	**79.25**	**58.74**	**11.05**	—	—	—	**3.68**	**6.42**	**4.77**	**2.27**	**5.50**	**21.21**	**1.23**	**8.73**	**3.96**	**57.76**	**60.05**	**70.80**	**76.30**
Soft coke	0.15	—	—	—	—	0.13	—	—	—	—	—	—	—	—	—	—	—	—	0.02
Petroleum refining	—	58.74	—	—	—	—	1.74	6.42	4.77	2.27	5.50	21.38	1.40	9.44	3.96	56.88	—	—	1.86
Liquefied petroleum gas extraction	—	—	1.94	—	—	—	1.94	—	—	—	—	—	—	—	—	1.94	—	—	—
Power generation	79.11	—	5.50	6.11	0.67	—	—	—	—	—	—	0.17	0.17	0.71	—	1.05	85.66	92.44	92.44
Conversion losses	52.74	—	3.91	4.08	0.45	—	—	—	—	—	—	0.12	0.12	0.47	—	0.70	57.34	61.87	61.87
Auxiliary consumption power station	2.64	—	0.03	0.01	0.02	—	—	—	—	—	—	0.01	0.01	0.02	—	0.04	2.70	2.74	2.74
Transmission and distribution loss	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.20	6.20
Flaring of natural gas, etc.	—	—	3.61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.61
Net availability	**60.06**	—	**8.07**	—	—	**0.13**	**4.35**	**3.94**	**5.01**	**2.22**	**9.74**	**33.21**	**1.18**	**5.69**	**4.03**	**69.36**	**25.61**	**21.64**	**159.26**
Consumption	**60.06**	—	**8.07**	—	—	**0.13**	**4.35**	**3.94**	**5.01**	**2.22**	**9.74**	**33.21**	**1.18**	**5.69**	**4.03**	**69.36**	—	**21.64**	**159.26**
Agriculture	—	—	0.08	—	—	—	0.00	0.00	0.00	0.00	0.00	0.82	0.04	0.21	0.00	1.07	—	7.25	8.41
Industry	59.94	—	1.74	—	—	—	0.83	0.00	0.00	0.00	0.00	2.47	0.73	4.76	0.00	8.79	—	7.04	77.51
Transport	0.12	—	—	—	—	—	0.00	0.00	5.01	2.22	0.00	29.02	0.07	0.32	0.00	36.63	—	0.44	37.19
Residential	—	—	0.14	—	—	0.08	3.45	0.00	0.00	0.00	8.16	0.00	0.00	0.00	0.00	11.61	—	3.43	15.25
Other energy uses	—	—	—	—	—	0.05	0.07	0.00	0.00	0.00	1.58	0.91	0.34	0.40	0.00	3.30	—	3.48	6.83
Non-energy uses	—	—	6.11	—	—	—	0.00	3.94	0.00	0.00	0.00	0.00	0.00	0.00	4.03	7.97	—	0.00	14.08

Note
Figures may not add up to total due to rounding-off.
Source
Compiled by TERI, New Delhi

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Table 2

Commercial energy balance (million tonnes of oil equivalent): 1996/97

	Primary energy					Secondary energy													
Supply–demand and sources	Coal	Oil	Natural gas	Hydro	Nuclear	Soft coke	Liquefied petroleum gas	Naphtha	Motor gasoline	Aviation turbine fuel	Kerosene	High speed diesel	Light diesel oil	Fuel oil	Other petroleum products	Total petroleum products	Thermal power	Total power	Total energy
Supply																			
Production	151.32	32.90	19.49	5.14	0.76	—	—	—	—	—	—	—	—	—	—	—	—	5.90	209.62
Imports	7.02	33.91	—	—	—	—	1.26	0.02	—	0.16	5.00	14.08	—	—	1.13	21.66	—	—	62.58
Exports	0.05	—	—	—	—	—	0.03	2.35	—	—	—	0.22	—	0.08	3.67	6.34	—	—	6.39
Stock changes	11.72	3 94	—	—	—	—	0 33	−1.09	−0.27	0.12	1.44	0.60	0.07	−0.45	−2.59	−1.85	—	—	13.81
Availability	**146.57**	**62.87**	**19.49**	**—**	**—**	**—**	**0.91**	**−1.24**	**0.27**	**0.04**	**3.56**	**13.27**	**−0.07**	**0.37**	**0.06**	**17.16**	**—**	**—**	**252.00**
Conversion	**83.73**	**62.87**	**11.12**	—	—	—	**3.82**	**6.58**	**5.03**	**2.26**	**6.52**	**22.75**	**1.14**	**7.78**	**4.26**	**60.13**	**64.45**	**75.31**	**80.88**
Soft coke	0.15	—	—	—	—	0.06	—	—	—	—	—	—	—	—	—	—	—	—	0.08
Petroleum refining	—	62.87	—	—	—	—	1.81	6.58	5.03	2.26	6.52	22.98	1.33	10.14	4.26	60.91	—	—	1.96
Liquefied petroleum gas extraction	—	—	2.01	—	—	—	2 01	—	—	—	—	—	—	—	—	2.01	—	—	—
Power generation	83.58	—	5.59	5.14	0.76	—	—	—	—	—	—	0.23	0.19	2.36	—	2.79	91.95	97.85	97.85
Conversion losses	55.72	—	3.97	3.43	0.51	—	—	—	—	—	—	0.16	0.13	1.58	—	1.86	61.54	65.48	65.48
Auxiliary consumption in power station	2 79	—	0.03	0.01	0.03	—	—	—	—	—	—	0.01	0.01	0.08	—	0.09	2.91	2.95	2.95
Transmission and distribution loss	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.89	6.89
Flaring of natural gas, etc.	—	—	3.52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.52
Net availability	**62.84**	**—**	**8.37**	**—**	**—**	**0.06**	**4.73**	**5.34**	**5.30**	**2.30**	**10.08**	**36.01**	**1.07**	**8.15**	**4.32**	**77.30**	**27.50**	**22.54**	**171.11**
Consumption	**62.84**	—	**8.37**	—	—	**0.06**	**4.73**	**5.34**	**5.30**	**2.30**	**10.08**	**36.01**	**1.07**	**8.15**	**4.32**	**77.30**	—	**22.54**	**171.11**
Agriculture	—	—	0.10	—	—	—	0.00	0.00	0.00	0.00	0.00	0.60	0.04	0.27	0.00	0.91	—	7.33	8.34
Industry	62.80	—	1.99	—	—	—	0.88	0.00	0.00	0.00	0.00	2.92	0.66	7.06	0.00	11.51	—	7.65	83.95
Transport	0.04	—	—	—	—	—	0.00	0.00	5.30	2.30	0.00	31.42	0.07	0.35	0.00	39.44	—	0.50	39.97
Residential	—	—	0.14	—	—	0.04	3.78	0.00	0.00	0.00	8.45	0.00	0.00	0.00	0.00	12.23	—	3.71	16.11
Other energy uses	—	—	—	—	—	0.02	0.08	0.00	0.00	0.00	1.63	1.08	0.31	0.47	0.00	1.71	—	3.36	6.95
Non-energy uses	—	—	6.14	—	—	—	0.00	5.34	0.00	0.00	0.00	0.00	0.00	0.00	4.32	11.68	—	0.00	15.80

Note

Figures may not add up to totals due to rounding-off.

Source

Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Table 3

Commercial energy balance (million tonnes of oil equivalent): 1997/98

	Primary energy					Secondary energy													
Supply–demand and sources	Coal	Oil	Natural gas	Hydro	Nuclear	Soft coke	Liquefied petroleum gas	Naphtha	Motor gasoline	Aviation turbine fuel	Kerosene	High speed diesel	Light diesel oil	Fuel oil	Other petroleum products	Total petroleum products	Thermal power	Total power	Total energy
Supply																			
Production	156.96	33.86	22.63	6.28	0.85	—	—	—	—	—	—	—	—	—	—	—	—	7.13	220.57
Imports	8.44	34.49	—	—	—	—	1.48	2.02	—	0.06	5.22	14.57	—	—	0.97	24.32	—	—	67.25
Exports	0.05	—	—	—	—	—	0.02	1.51	—	—	—	0.25	—	0.36	1.83	3.97	—	—	4.02
Stock changes	14.81	3.19	—	—	—	—	0.16	1.13	–0.33	0.09	1.91	1.02	0.01	–0.50	–1.09	2.41	—	—	20.41
Availability	**150.54**	**65.17**	**22.63**	—	—	—	**1.30**	**–0.63**	**0.33**	**–0.03**	**3.31**	**13.30**	**–0.01**	**0.14**	**0.23**	**17.94**	—	—	**263.39**
Conversion	**89.56**	**65.17**	**12.56**	—	—	—	**3.90**	**6.56**	**5.19**	**2.29**	**7.00**	**23.95**	**1.10**	**8.50**	**4.00**	**62.48**	**69.52**	**81.67**	**87.31**
Soft coke	0.00	—	—	—	—	0.00	—	—	—	—	—	—	—	—	—	—	—	—	0.00
Petroleum refining	—	65.17	—	—	—	—	1.88	6.56	5.19	2.29	7 00	24.17	1.29	10.91	4.00	63.29	—	—	1.88
Liquefied petroleum gas extraction	—	—	2.02	—	—	—	2.02	—	—	—	—	—	—	—	—	2.02	—	—	—
Power generation	89.56	—	6.77	6 28	0.85	—	—	—	—	—	—	0.23	0 19	2.42	—	2.83	99.16	106.29	106.29
Conversion losses	59.71	—	4 80	4.19	0.56	—	—	—	—	—	—	0.15	0.13	1.61	—	1.89	66.40	71.15	71.15
Auxiliary consumption in power station	2.99	—	0.04	0.01	0.03	—	—	—	—	—	—	0.01	0.01	0.08	—	0.09	3.12	3.16	3.16
Transmission and distribution loss	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.36	7.36
Flaring of natural gas, etc.	—	—	3.77	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.77
Net availability	**60.98**	—	**10.07**	—	—	**0.00**	**5.20**	**5.93**	**5.51**	**2.26**	**10.31**	**37.25**	**1.09**	**8.64**	**4.22**	**80.42**	**29.64**	**24.62**	**176.08**
Consumption	**60.98**	—	**10.07**	—	—	**0.00**	**5.20**	**5.93**	**5.51**	**2.26**	**10.31**	**37.25**	**1.09**	**8.64**	**4.22**	**80.42**	—	**24.62**	**176.08**
Agriculture	—	—	0.11	—	—	—	0.00	0.00	0.00	0.00	0.00	0.64	0.04	0.27	0.00	0.94	—	7.70	8.75
Industry	60.94	—	2.92	—	—	—	0.96	0.00	0.00	0.00	0.00	2.99	0.67	7.12	0.00	11.74	—	8.49	84.09
Transport	0.04	—	—	—	—	—	0.00	0.00	5.51	2.26	0.00	32.50	0.07	0.61	0.00	40.95	—	0.57	41.55
Residential	—	—	0.27	—	—	0.00	4.16	0.00	0.00	0.00	8.64	0.00	0.00	0.00	0.00	12.80	—	4.15	17.22
Other energy uses	—	—	—	—	—	0.00	0.08	0.00	0.00	0.00	1.67	1.12	0.32	0.64	0.00	3.83	—	3.72	7.55
Non energy uses	—	—	6.77	—	—	—	0.00	5.93	0.00	0.00	0.00	0.00	0.00	0.00	4.22	10.15	—	0.00	16.92

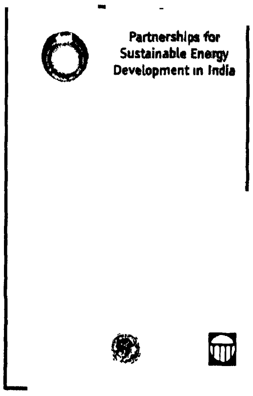
Note
Figures may not add up to totals due to rounding-off.
Source
Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Partnerships for Sustainable Energy Development in India

(Proceedings of the Conference held on 28 October 1998 in Washington, DC, USA)

This book is the proceedings of the Conference on Partnerships for Sustainable Energy Development in India held in Washington, DC, USA. The conference was an attempt to identify the potential and the means of exploring possibilities of partnerships and collaborative activities between the world's two largest democracies – India and the US. Keeping both the global and local environmental perspectives in mind, business opportunities were identified in the fields of energy and environment, in areas such as power generation and transmission, rural energy, agriculture, biotechnology, renewable energy sources, and management systems.



Partnerships for
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ENERGY SUPPLY

Coal and lignite

Overview

The Geological Survey of India has estimated India's proven coal reserves at 79 106 MT (million tonnes), which is approximately seven per cent of the total world reserves as on 1 January 1999 (Table 2). Estimates of the total coal resources are much higher at 208 751 MT up to a depth of 1200 metres. As a result, coal has become India's most important primary source of energy.

Although the reserves are substantial as shown in Table 2, Indian coal is generally of poor quality with high ash content and low calorific value. In addition, some of the major consumption sites are located unfavourably in relation to the reserves placing an enormous burden on the transport infrastructure (Map 1, Appendix II).

Lignite reserves in the country have been estimated at around 29 360 MT. Of this 26 000 MT is in Tamil Nadu and Pondicherry, the rest in Gujarat, Rajasthan, and Jammu and Kashmir (Table 3).

At present, India ranks third amongst the coal-producing countries of the world. The CIL (Coal India Limited) and its subsidiaries are the major producers of coal, contributing approximately 88% of the coal produced in India. Through a sustained programme of investment and greater thrust on application of modern technologies, it has been possible to raise the production of coal to 306 MT in 1998/99 as compared to 100 MT in 1975/76. In order to meet the country's growing demand for coal, collaboration with advanced coal-producing countries is being sought in terms of:

- introducing new technologies in both underground and opencast mining;
- bilateral funds for equipment import; and
- increasing investment through foreign financial assistance.

Opencast mining has increased by a factor of 20 during 1980/81 to 1997/98 (Figure 1). The total production from surface mines is about 225 MT, accounting for nearly 75% of the total coal production. In spite of substantial investment in the coal sector, underground mining has made little progress in terms of productivity due to difficult mining conditions, low levels of skill, and a large workforce. Since 1996/97, the growth rates for underground and opencast mining are 0.7% and 7.6%, respectively.

There has been a substantial improvement in the productivity or overall OMS (output per man-shift) during the last decade for CIL and the SCCL (Singareni Collieries Company Limited) group of companies (Figure 2). The overall productivity is 2.0 for the CIL and 1.3 for the SCCL. Comparative performances of other countries include an average of 37.5 tonnes per man-shift in the US in 1994 and 43 tonnes per man-shift in Germany's Hambach

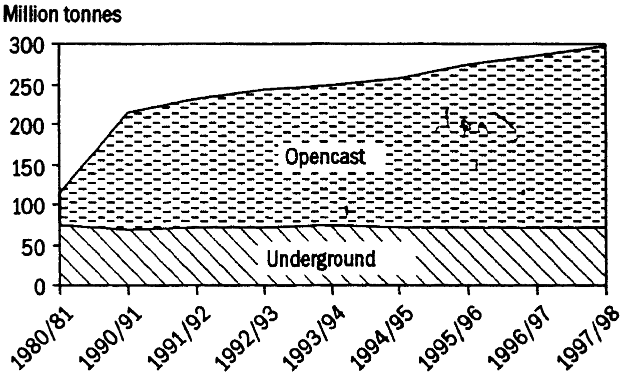

Figure 1 All-India coal production by technology type
Source MoC (1998)

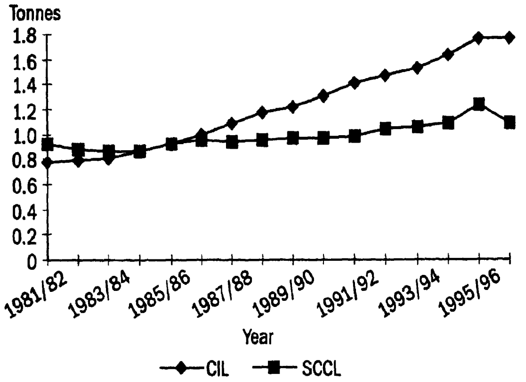

Figure 2 Overall output per man-shift for the CIL (Coal India Limited) and the SCCL (Singareni Collieries Company Limited)
Source MoC (1998)

lignite mine. While the OMS for opencast mining has improved, the OMS for underground mining has either declined or stagnated (Table 12).

Quality and preparation

Coking coal reserves in the country are limited and only two to three per cent of the total coal reserves fall into the prime coking category. Most of the coking coal occurs in Bihar. Among these deposits, the coal in Jharia has the highest coking property even though the ash content is inherently quite high (about 21%). After suitable beneficiation, this coal, referred to as prime coking coal, can be used to produce coke of the prescribed quality required by the steel plants. Coking coal in other coalfields can yield suitable coke only when blended with prime coking coal and it is termed as medium coking coal. The quality attributes for coal from the Raniganj and Jharia coalfields are given in Table 15.

Most of the coking coal washing plants in India are old and have low unit capacity. Of the 20 washeries currently in operation, only one has an annual output of over 1 MT of washed coking coal and three have individual outputs of less than 300 000 tonnes a year. In addition, capacity utilization is also low typically in the order of 50%–65% and is expected to decline to about 48% by the end of the Ninth Plan. The details on raw coal feed and clean coal production by washery are provided in Table 17. The CIL has been having problems in maintaining its contractual obligations relating to a 17% maximum ash content in the coking coal supplied to SAIL (Steel Authority of India Limited) as specified in the Altekar Committee in 1994/95 (Planning Commission 1996). Due to high ash content in the coal supplied to the steel industry (greater than 17%), the import dependency for coking coal is steadily increasing.

Majority of non-coking coal reserves in India occur in thick inter-banded seams and are of inferior quality. Due to the poor quality of non-coking coal received by the power stations, fly ash disposal becomes a critical problem. However, the MoEF (Ministry of Environment and Forests) has ensured supply of clean coal (34% ash content) to all power stations located beyond 1000 km from the coalfields and to those located in critically-polluted and sensitive urban areas with effect from 1 June 2001. A Gazette Notification to this effect was issued on 19 September 1997. Currently, about 37% (100 MT) of non-coking coal is transported to power plants located beyond 1000 km from the coalfields (Table 20). Furthermore, under the current proposal, there would be a phased introduction of maximum 34% ash in power station feed between 2000 and 2004 with all new generating capacity constructed after June 2000 designed to use this fuel.

Despite having long-term targets for the construction of about 60 MT annual washing capacity for non-coking coal, the construction of washing plants has not kept pace with the increasing coal-mining capacity. As a result, large quantities of unwashed coal are being transported to power stations placing a severe constraint on the country's bulk freight services' capacity.

The CIL does not set up any washery of its own, other than on BOO (build-own-operate) or BOOT (build-own-operate-transfer) basis, due to the large costs and gestation period involved. In view of this, the Coal Mines Nationalization Act, 1973, was amended and about 20 MT of capacity is under construction/planning with the private sector. The Government of Andhra Pradesh also selected this route for providing washed coal from the SCCL's mines with a call for BOO tenders for the construction of three 8000-tonnes-per-day washeries at Manguru, Rudrampur, and Yellandu. The progress, however, has been very slow.

Transportation

With much of the coal production in the eastern part of the country, and consumers such as power stations and steel works located elsewhere, transport becomes a major consideration. The railway is the main mode of coal transport in India, followed by captive systems such as merry-go-rounds. Road transport, conveyors, and aerial ropeways are also used. Sea-borne movements account for about six per cent of India's domestic coal transport. Coastal shipment is used for supplying coal to consumers in southern India.

The inter-modal split for coal dispatches is given in Table 18. It can be observed that the share of railways has decreased over the years. While the production of coal increases by approximately 5.6% annually, the rail movement increases at 3.8% only. The constraints on the rail evacuation facility have resulted in significant pithead stocks. Movement by rail has been observed to be constrained particularly in areas like Korba, Talcher, Ib Valley, North Karanpura, and Rajmahal, which have large potential for production.

Long-distance coal movements take place on well-defined routes as listed below.

- From coalfields in the east to northern India through Mughalsarai
- From coalfields in the east to central and western India through Ajni and Katni
- From coalfields in the east to southern India through Waltair
- From coalfields in central India to southern and western India

India has 11 major ports which are managed by the Port Trust of India, under the jurisdiction of the Central Government. A significant quantity of coal (currently about 11 MT a year) is carried by rail over relatively short distances to the eastern ports for onward coastal shipping to southern India. Haldia, Paradip, and Vishakapatnam are the most important ports on India's eastern coast. Around 11 MT of coal is shipped out of these ports each year, destined mainly for the southern ports of Chennai and Tuticorin. Coking coal imports are also received at these ports. It was envisaged that coal movement from the eastern region to the power plants in the southern and western regions would be based on a carefully drawn-up action plan necessitating the movement of coal by coastal shipping, thereby easing the pressure on the railways.

The government has recently allowed private sector participation in the development and augmentation of port facilities. Large users such as power stations, steel manufacturers, and cement producers are also being encouraged to develop their own coal-handling facilities.

Plan outlay and expenditure

The Eighth Five-Year Plan envisaged the coal industry to be financially viable and self-supporting through improvements in efficiency and productivity. Decontrol of prices has therefore been proposed to increase the generation of resources internally to reduce the reliance on budgetary support. The government also approved capital restructuring for the SCCL and the CIL during this period. However, due to delays in revising coal prices, prior to the decontrol of certain grades of coal, the benefits of capital restructuring have been diluted.

The Eighth Plan approved a central outlay of 113 570 million rupees (at 1991/92 prices) for the coal and lignite sector. This outlay did not include the contribution of the Government of Andhra Pradesh towards its share of equity in the SCCL, which is estimated at 8500 million rupees. In addition, the outlay approved for the Neyveli Lignite Corporation (power) was 10 000 million rupees. Of the total outlay of 123 570 million rupees, the net budgetary support indicated by the government was 17 950 million rupees (14.5%) and another 9860 million rupees was proposed to be generated by external assistance routed through the budget. As against this, the cumulative expenditure during the Plan period has been around 101 940 million rupees. The expenditure thus forms about 80% of the total outlay at current prices and about 71% at constant prices (1991/92). The main reasons for the shortfall in expenditure have been the delay in the revision of coal prices and non-realization of outstanding coal sales dues, affecting the generation of internal resources. The total outstanding dues to coal companies in July 1999 since 1 January 1997 from various clients, including state electricity boards, has amounted to 52 726 million rupees. The delays in payment have adversely affected production targets.

Also the envisaged market borrowings have not materialized as per schedule, thus affecting the Plan expenditure adversely. The net budgetary support as a percentage of actual plan expenditure for the Eighth Five-Year Plan is provided in Table 32. Based on the progress of the coal projects, the spillover to the Ninth Plan period is 74 460 million rupees. The Ninth Plan outlay has been fixed at 175 752.3 million rupees at 1996/97 prices.

Conservation initiatives

Some of the areas that require immediate attention for coal conservation are listed below.

- Improvement in the productivity of men and machines, capacity utilization, technology and project implementation
- Improvements in the quality of coal and in the share of underground mining in the total coal production
- Rationalization of coal prices
- Restructuring of the coal industry
- Development of rail and port infrastructure
- Development of more power plants at pitheads to ease infrastructure constraints
- Introduction of demand-side management initiatives
- Extending infrastructure benefits to the coal and lignite sectors
- Utilization of coal-bed methane
- Computerization of sales and transparency in operations

Legislation

Coal exploration and mining in India is governed by the Mines Act, 1952; the Mines and Minerals (Regulation and Development) Act, 1957; the Coal Mines Regulation Act, 1957; the Coal Mine (Nationalization) Act, 1973; the Forest Conservation Act, 1980; and the Environment (Protection) Act, 1986. Opening of new mines and subsequent operations require statutory permission from the Ministry of Coal, the Director General of Mine Safety, the MoEF, the State Pollution Control Board, and the respective state governments.

A mining lease that allows for the development and exploitation of coal needs to be obtained before undertaking any mining operations. It is granted by the state government after it is approved by the Government of India under the Mines and Minerals (Regulations and Development) Act, 1957. Mining leases are granted for 30 years initially and are renewed for a period of 20 years with the government's approval. The lease is ordinarily subject to a ceiling of 10 square kilometres of area.

The legal and regulatory framework needs to reflect the policy of the government. Coal mining projects in India are required to address environmental and social issues. The Environment Action Plan, the Rehabilitation Action Plan, and the Indigenous People's Development Plan are now an integral part of any coal project. The revision of the legislative framework, however, has not kept pace with the evolving policy that aims at reducing the role of the government as a developer of resources. The legislative provisions, therefore, need to operate within a framework that is beneficial for the investors and provides accessibility to latest technologies in the coal industry.

Reforms in the coal sector

Phased liberalization of the coal sector was initiated during the economic reforms in 1992. The initial package of reforms permitted private sector investments only in captive coal mines of selected end-use industries, namely, steel, power, and cement. With the exception of Bengal EMTA (Eastern Mining and Trading Association), which produces 2 MT of coal for power generation, production from these projects is yet to materialize. Recently, SAIL has been allocated the Tasra coal block in the Jharia coalfields for captive coal mining. Moreover, the post-reform period witnessed a deceleration in the production of domestic coal with a growth rate of a little over four per cent a year. This is lower than the six per cent growth achieved during the regime of a regulated coal industry (1975–92). Obviously, the partial deregulation measures did not bring about the expected incremental supply from the private sector. In addition, the import of coal, especially non-coking coal, has increased in the post-liberalization period.

Considering the importance of the coal and lignite sector in determining an energy strategy for the country and the need for developing these resources, the Planning Commission constituted the CICP (Committee on Integrated Coal Policy), which submitted its report in May 1996. The Committee framed its recommendations on the central premise that a conducive policy environment has to be created for attracting private investments. The recommendations, therefore, seek to augment the production of coal and lignite through private sector participation, deregulation of coal prices, coal conservation through reduction of specific consumption in power generation and steel making, augmentation of transportation infrastructure, creation of a regulatory authority for resolving price disputes and amendments in various acts for facilitating the implementation of these recommendations (Planning Commission 1996a).

The following recommendations have been accepted, in principle, by the Government of India (Planning Commission 1999).

- Set up an independent body to monitor the detailed and regional exploration of coal and lignite resources
- Allocate new coal mining blocks on the basis of a competitive bidding process in which Indian companies, including national coal companies, may participate
- Permit any Indian company subject to legislative approval to mine coal without the restriction of captive consumption
- Introduce total decontrol of prices and linkages for coal from 1 January 2000
- Grade and price non-coking coal based on gross calorific value rather than the useful heat value in line with international practices
- Negotiate for the fuel-supply agreement for supplying coal to over 20 IPPs (independent power producers)
- Establish a regulatory body, which would perform an appellate function to resolve any price disputes between the producers and consumers
- Amend various laws and statutes for the implementation of these recommendations

Deregulation of coal mining

Faced with the projected increases in demand for coal, the Coal Mines Nationalization Act, 1973, was amended with effect from 9 June 1993 for the operation of captive coal mines by companies engaged in the production of iron and steel and power. Cement was also notified as an end-use with effect from 15 March 1996 for the purpose of captive coal mining. Until now, about 20 blocks have been allotted as captive coal mining blocks.

At present, the captive mining system has failed to deliver the increases in coal output that had been anticipated. This is mainly a result of the many restrictions imposed on private developers and the numerous clearances that are required from the various government agencies. In particular, captive mines are allowed to supply their output to a single captive customer. Even if the main customer is unwilling or unable to take the entire output, the captive coal producer cannot sell coal to alternative consumers. In addition, many developers consider the risks involved with the projects to be very high.

Pricing reforms

In keeping with the recommendations of the Expert Committee, the second round of deregulation occurred in 1996. Following the recommendations of the BICP (Bureau of Industrial Costs and Prices), a decision was taken by the government to deregulate the prices of coking coal and superior grades (A, B, C) of non-coking coal. Accordingly, prices of these grades have been deregulated vide notification dated 22 March 1996. Prices of deregulated coking coal and superior grades of non-coking coal have been revised by the CIL with effect from 31 March 1996.

On 11 February 1997, the government decided to deregulate the price of 'D' grade non-coking coal, hard coke, and soft coke with immediate effect. It also allowed the CIL and the SCCL to fix the prices of E, F, and G grades (power grade) of non-coking coal once every six months by updating the cost indices as per the escalation formula contained in the 1987 report of the BICP, till 1 January 2000. Thereafter, the CIL and the SCCL, will fix the prices of lower grades of non-coking coal according to market prices. The CIL and the SCCL are expected to increase the prices of E, F, and G grades of coal in relation to the market prices from 1 January 2000. The distribution of these coals will also be deregulated with effect from 1 January 2000.

Regional prices of coal have started emerging as a result of the recent revision in the pricing mechanism. This implies that the price of the same grade of coal will not be the same for all the coalfields any more. This is clearly a precursor to the total decontrol of prices and linkages (Table 29).

Prior to the deregulation of coal prices, the government had approved coal projects for a lower RoR (rate of return) of 12% in the larger economic interest of the country. Now, with deregulation of coal prices in place, a change in the economics of coal projects is expected. However, in view of the mounting losses of the coal companies, the Ministry of Coal has decided not to consider any projects for approval with less than 16% RoR. This has resulted in the shelving of several coal projects, leading to an unwelcome trend in the demand–supply mismatch. Since coal projects have a long gestation period and therefore cannot be executed in a short span, the recommendation of the CICP regarding negotiating prices for any coal produced from the new coal mines is highly beneficial. The selling price of coal from these projects needs to be worked out through commercial agreements between the producer and the consumer so as to yield the required RoR.

Fiscal reforms

Imports of coal are being allowed under the Open Generalized License. The basic import tariff or customs duty on coking coal is 3%, whereas that on non-coking coal has been reduced to 10%. The additional duty on coking and non-coking coal has been fixed at five per cent.

The main features of the proposed fiscal reforms in the coal sector are listed below.

- Mining and sale of coal at market-determined prices by private companies
- Foreign investors can hold equity in Indian companies in the coal sector or float 100% subsidiaries for mining and exploration ventures
- Foreign equity participation exceeding 50% will be subject to approval by the FIPB (Foreign Investment Promotion Board) and will have to be registered with the Registrar of Companies

Policy recommendations

In a liberalized economy, competition is the guiding factor for reliable product and services. Currently, 98% of coal is produced from national coal companies, of which 88% is produced by the CIL and 10% by the SCCL. As such, there is no competition in the industry and it is therefore necessary to inculcate the spirit of competition.

Private sector participation needs to be facilitated so as to bring about competition amongst the coal producers and hence prevent cartelization for price control. It is imperative to bring about the necessary legislative changes to facilitate private sector participation in coal production and distribution. Even though some changes have been initiated, efforts are required to further streamline the administrative procedures to expedite the necessary clearances and the required legislative changes (Sengupta 1999).

Further, forming joint ventures between the public and private sector coal companies and the concerned state government may reduce delays in new projects due to paucity of funds. This will not only aid the resolution of procedural difficulties in project implementation but also overcome problems related to land acquisition, rehabilitation of people ousted from the land, and forest clearances.

Joint ventures will also bring in consumer satisfaction with regard to quality and assured supply of coal economically. Some of the IPPs, for instance, may have the resources to take up mining but they may not have the expertise, in which case they may like to enter into equity participation with the existing coal companies. Similarly, public sector utilities, such as the National Thermal Power Corporation, may like to enter into equity participation with the coal producers like the SCCL and the CIL for their proposed pithead power stations. In addition, SAIL and other steel producers in the private sector may enter into joint ventures with the CIL for developing new coking coal mines instead of relying on imports for their future requirements.

Due to the pre-liberalization structure of the coal industry, with a high degree of concentration of reserves and assets with the nationalized producers, the infrastructure bottlenecks, and the statutory and legal barriers, the Indian coal sector may not operate under conditions of competitive price-setting over the medium term. Moreover, the transition from a monopoly to a competitive system requires balancing of interests of the various participants in the market. This implies that a regulatory body will be indispensable.

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Table 1

Coal resources of states (million tonnes): 1 January 1999

State	*Proved*	*Indicated*	*Inferred*	*Total*
Andhra Pradesh	7094.82	3313.78	2928.67	13337.27
Arunachal Pradesh	31.23	11.04	47.96	90.23
Assam	259.37	26.83	34.01	320.21
Bihar	34401.00	28420.83	5934.77	68756.60
Madhya Pradesh	12502.72	21795.24	8474.47	42772.43
Maharashtra	3927.53	1357.37	1684.17	6969.07
Meghalaya	117.83	40.89	300.71	459.43
Nagaland	3.43	1.35	15.16	19.94
Orissa	9623.10	21990.91	17447.19	49061.20
Uttar Pradesh	574.80	487.00	—	1061.80
West Bengal	10570.36	10981.29	4352.06	25903.71
Total	**79106.19**	**88426.53**	**41219.17**	**208751.89**

Source
MoC. 1999. Annual Report 1998/99. New Delhi. Ministry of Coal

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 2

Coal reserves by category (million tonnes): 1 January 1999

Types of coal	*Proved*	*Indicated*	*Inferred*	*Total*
Coking *				
Prime coking	4614.35	698.71	—	5313.06
Medium coking	11250.53	10692.09	1214.91	23157.53
Blendable/semi-coking	482.16	904.04	221.68	1607.88
Sub-total	16347.04	12294.84	1436.59	30078.47
Non-coking*	62759.15	76131.69	39782.58	178673.42
Total (Coking and non-coking)	**79106.19**	**88426.53**	**41219.17**	**208751.89**

* including coals of the north-eastern region

Source
MoC 1999. Annual Report 1998/99 New Delhi: Ministry of Coal

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 3

Lignite reserves of states and union territories (million tonnes): 1998/99

State/Union territory	*Geological reserves*
Tamil Nadu and Pondicherry	3300
Neyveli	575
Bahur	1167
Jayamkondacholapuram	19500
Mannargudi	1420
East of Veeranam	133
Kudikadu	23
Perambalur	1496
Rajasthan	1505
Gujarat	128
Kerala	108
Total	**29355**

Source

MoC. 1999. Annual Report 1998/99. New Delhi. Ministry of Coal

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 4

Drilling details for coal exploration of companies and agencies: 1997/98 and 1998

Agency/coal company	*1997/98* *Annual target (metres)*	*Achievements in 1997/98 (metres)*	*Achievements against annual target (%)*	*1998* *Annual target (metres)*	*Achievements during April–December 1998 (metres)*	*Achievements against annual target (%)*
CMPDIL (Central Mine Planning and Design Institute Limited)	170000	185141.45	108.91	192000	135638.00	70.64
MECL (Mineral Exploration Corporation)	84000	74384.50	88.55	62500	53780.95	86.05
State government DGM (Director of Geology and Mining),Madhya Pradesh/South Eastern Coalfields Ltd	5000	6629.61	132.59	5000	4870.48	97.41
DGM, (Director of Geology and Mining), Orissa/Mahanadi coalfields Ltd	9500	7706.35	81.12	5000	1960.80	39.22
Private parties	1500	917.65	61.18	1500	488.50	32.57
Grand total	**270000**	**274779.56**	**101.77**	**266000**	**196738.73**	**73.96**

Source

MoC. 1999. Annual Report 1998/99 New Delhi Ministry of Coal.

Table 5

All-India production of coal, lignite, and other derivatives (million tonnes): 1975/76 to 1997/98

Items	*1975/76*	*1980/81*	*1985/96*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Coking coal	27.4	31.7	35.2	44.9	45.8	45.2	44.7	42.0	39.9	40.5	43.8
Non-coking coal	72.3	82.3	119.1	169.0	187.0	196.8	204.0	215.8	233.5	245.5	253.3
Total coal *	**99.7**	**114.0**	**154.3**	**213.9**	**232.8**	**242.0**	**248.7**	**257.8**	**273.4**	**286.1**	**297.2**
Lignite	3.0	5.1	8.0	14.1	16.0	16.6	18.1	19.3	22.2	22.6	23.1
Total coal and lignite	**102.7**	**119.1**	**162.3**	**225.7**	**245.4**	**255.1**	**266.8**	**277.1**	**295.6**	**308.7**	**320.2**
Soft coke	2.7	2.3	1.7	0.9	0.7	0.5	0.4	0.3	0.2	0.1	—
Beehive hard coke	0.8	0.6	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
By-product hard coke	0.6	0.4	0.3	10.2	10.5	10.6	10.6	10.9	10.9	11.0	10.6
Washed coal	11.4	11.6	10.9	11.2	12.5	12.8	12.1	11.8	11.9	10.9	10.0
Middlings	3.9	4.3	5.1	5.6	6.1	6.5	6.6	6.3	6.8	6.8	7.6
Total exports	**0.4**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Total imports	—	**0.6**	**2.0**	**4.9**	**5.9**	**6.7**	**7.1**	**8.3**	**8.9**	**9.5**	**9.5**

* includes Meghalaya figures for the unorganized sector

Source

CCO. Coal Directory of India (various issues). Calcutta: Coal Controller's Organization, Ministry of Coal.

For more details, please see TEDDY ONLINE+ Section: [Coal (general, production, and despatch)]

Table 6

Coal production, despatches, and pithead stock of various states (million tonnes): 1975/76 to 1997/98

Year	Andhra Pradesh	Assam	Bihar	Madhya Pradesh	Maharashtra	Orissa	Uttar Pradesh	West Bengal	Meghalaya	All-India
Production										
1975/76	7.4	0.6	41.8	20.4	3.7	2.2	—	23.7	—	99.8
1980/81	10.1	0.6	46.6	25.9	5.8	3.2	1.8	20.0	—	114.0
1985/86	15.7	0.9	54.3	42.6	11.6	6.0	3.9	19.4	—	154.4
1990/91	17.7	0.7	67.3	65.2	16.9	16.2	10.5	17.2	2.2	213.9
1991/92	20.6	1.0	69.0	69.4	18.9	20.7	11.5	18.2	3.5	232.8
1992/93	22.5	1.1	71.1	70.7	19.7	23.1	12.2	18.1	3.5	242.0
1993/94	25.3	1.2 *	73.3	72.9	20.5	24.3	12.1	16.6	2.5	248.7
1994/95	25.7	1.2 *	73.3	74.9	21.1	27.3	13.8	17.2	3.3	257.8
1995/96	26.8	0.8	74.6	79.8	22.8	32.7	14.8	17.9	3.3 †	273.5
1996/97	28.7	0.8	77.7	83.3	24.9	37.4	15.4	18.0	—	286.1
1997/98	28.9	0.7	81.2	84.4	26.5	42.6	15.8	17.5	—	297.2
Despatches										
1975/76	7.0	0.6	33.1	19.5	3.4	2.0	—	21.2	—	86.8
1980/81	10.1	0.1	39.1	24.6	5.7	2.8	1.6	17.3	—	101.3
1985/86	15.4	0.8	53.7	42.0	11.7	5.3	3.6	18.5	—	151.0
1990/91	24.6	0.9	60.8	62.8	17.4	16.0	10.2	15.7	2.2	210.6
1991/92	20.0	1.0	63.1	68.0	18.9	19.6	11.4	17.1	3.5	222.6
1992/93	21.7	0.9	69.4	69.7	19.1	21.9	11.6	16.3	3.5	234.1
1993/94	24.6	0.8 *	72.6	72.1	19.8	24.0	12.9	15.8	2.5	245.1
1994/95	24.0	0.8 *	73.2	73.1	21.2	26.9	13.7	16.2	3.3	252.4
1995/96	24.9	1.0 *	72.7	78.6	24.3	34.4	14.9	16.6	3.3 †	270.7
1996/97	28.8	0.8	76.0	83.7	24.7	37.2	15.7	16.7	—	283.7
1997/98	29.0	0.6	77.1	86.5	25.0	43.3	15.6	16.8	—	293.9
Pithead stock										
1975/76	0.5	—	6.8	1.7	0.2	0.4	—	2.2	—	11.8
1980/81	0.5	—	11.1	3.3	0.2	0.5	0.1	2.7	—	18.4
1985/86	0.6	0.2	16.5	6.1	0.8	2.1	0.2	2.5	—	29.0
1990/91	0.7	0.3	24.7	7.8	2.4	3.1	0.7	2.9	—	42.6
1991/92	0.7	0.1	29.4	8.4	2.1	4.1	0.8	2.9	—	48.5
1992/93	0.9	0.4	29.2	8.7	2.6	4.6	1.5	3.5	—	51.4
1993/94	0.9	0.8 *	28.5	8.9	3.0	4.8	0.6	3.1	—	50.6
1994/95	2.1	1.2 *	22.4	10.0	2.7	5.2	0.8	3.2	—	47.6
1995/96	2.5	0.9 *	22.9	10.6	1.0	3.4	0.7	3.7	—	45.7
1996/97	1.9	0.8	20.8	9.5	1.1	3.5	0.4	4.1	—	42.0
1997/98	1.4	0.9	23.4	7.1	2.0	2.3	0.4	3.9	—	41.5

* includes Arunachal Pradesh and Meghalaya under the north-eastern coalfields

† figures for the unorganized sector

Source

CCO. Coal Directory of India (various issues) Calcutta. Coal Controller's Organization, Ministry of Coal

[For more details, please see TEDDY ONLINE + [Section. Coal (general, production, and despatch)]

Table 7

Coal production, despatches, and pithead stock of various companies (million tonnes): 1993/94 to 1997/98

Year	*ECL*	*BCCL*	*CCL*	*SECL*	*MCL*	*WCL*	*NCL*	*NEC*	*CIL*	*SCCL*	*JKML*	*DVC*	*BECML*	*BSMDCL*	*IISCO*	*TISCO*
Production																
1993/94	22.61	29.04	33.51	47.53	24.30	26.50	31.41	1.20	216.10	25.28	0.02	0.07	—	—	0.72	3.96
1994/95	24.85	28.74	31.50	50.00	27.33	27.24	32.50	1.19	223.35	25.65	0.02	0.29	—	—	1.04	4.16
1995/96	27.80	27.81	30.75	53.17	32.70	29.01	35.20	0.82	237.35	26.77	0.02	0.23	—	—	0.99	4.90
1996/97	29.65	27.14	32.18	55.30	37.70	31.23	37.01	0.75	250.62	28.73	0.02	0.29	—	0.26	0.86	5.30
1997/98	27.44	30.92	33.10	56.63	42.16	32.51	37.56	0.69	261.01	28.94	0.01	0.36	0.70	0.20	0.72	5.23
Despatches																
1993/94	22.19	28.54	33.02	46.91	24.00	25.52	32.37	0.75	213.30	24.60	0.02	0.07	—	—	0.68	3.94
1994/95	24.22	28.34	31.18	47.81	26.93	27.26	32.92	0.83	219.49	25.04	0.02	0.27	—	—	1.03	4.28
1995/96	25.81	26.55	30.84	52.27	34.36	30.37	35.07	1.03	236.29	24.87	0.02	0.23	—	—	1.00	4.91
1996/97	28.04	26.75	31.19	56.12	37.22	30.91	37.09	0.83	248.15	28.82	0.02	0.29	—	0.26	0.87	5.29
1997/98	26.64	27.57	32.49	58.33	43.30	31.35	37.47	0.57	257.72	29.02	0.01	0.36	0.69	0.19	0.73	5.20
Pithead stock																
1993/94	6.55	13.29	11.51	7.07	4.82	3.52	1.91	0.82	49.48	0.95	0.01	—	—	—	0.27	0.05
1994/95	6.17	8.02	11.13	8.80	5.15	3.15	1.49	1.17	45.07	2.09	0.01	0.02	—	—	0.23	0.08
1995/96	7.21	8.56	10.57	9.22	3.40	1.44	1.61	0.87	42.87	2.52	—	—	—	—	0.21	0.05
1996/97	5.19	8.26	11.21	7.89	3.48	1.43	1.62	0.83	39.90	1.89	—	—	—	0.01	0.18	0.04
1997/98	5.09	10.95	11.03	6.01	2.29	2.29	1.27	0.93	39.84	1.38	—	—	0.02	0.01	0.17	0.04

ECL - Eastern Coalfields Ltd
BCCL - Bharat Coking Coal Ltd
CCL - Central Coalfields Ltd
SECL - South Eastern Coalfields Ltd
MCL - Mahanadi Coalfields Ltd
WCL - Western Coalfields Ltd
NCL - Northern Coalfields Ltd
NEC - North Eastern Coalfields
CIL - Coal India Ltd
SCCL - Singareni Collieries Company Ltd
JKML - Jammu and Kashmir Minerals Ltd
DVC - Damodar Valley Corporation
BECML - Bengal Emta Coal Mines Ltd
BSMDCL - Bihar State Mineral Development Corporation Ltd
IISCO - Indian Iron and Steel Company Ltd
TISCO - Tata Iron and Steel Company Ltd

Source
CCO. Coal Directory of India (various issues) Calcutta Coal Controller's Organization, Ministry of Coal.

Table 8

Production (million tonnes) of coking coal and non-coking coal by companies and fields: 1994/95 to 1997/98

Field	Companies	1994/95		1995/96		1996/97		1997/98	
		Coking	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*
West Bengal	BCCL	0.18	0.57	0.17	0.51	0.13	0.43	0.13	0.56
	ECL	0.14	15.82	0.13	16.68	0.15	16.95	0.09	15.70
	IISCO	0.02	0.51	0.01	0.42	0.03	0.30	0.05	0.16
	BECML	—	—	—	—	—	—	—	0.71
	Total	**0.34**	**16.90**	**0.31**	**17.61**	**0.31**	**17.69**	**0.27**	**17.13**
Bihar	BCCL	22.30	5.69	21.55	5.58	21.27	5.31	24.19	6.04
	ECL	0.29	8.60	0.24	10.76	0.22	12.33	0.21	11.44
	CCL	13.38	18.11	11.45	19.31	11.75	20.43	12.23	20.87
	DVC	—	0.29	—	0.23	—	0.29	—	0.36
	BSMDCL	—	—	—	—	—	0.26	—	0.20
	IISCO	0.51	—	0.56	—	0.52	—	0.51	—
	TISCO	4.16	—	4.90	—	5.30	—	5.23	—
	Total	**40.64**	**32.69**	**38.69**	**35.87**	**39.05**	**38.63**	**42.37**	**38.91**
Outlying fields	NCL	—	32.50	—	35.20	—	37.01	—	37.56
	SECL	0.13	49.87	0.16	53.01	0.48	54.83	0.47	56.16
	MCL	—	27.33	—	32.70	—	37.37	—	42.16
	WCL	0.86	26.39	0.75	28.25	0.70	30.52	0.74	31.78
	NEC	—	1.19	—	0.82	—	0.75	—	0.69
	SCCL	—	25.65	—	26.77	—	28.73	—	28.94
	JKML	—	0.02	—	0.02	—	0.02	—	0.01
	Total	**—**	**162.95**	**0.91**	**176.78**	**1.18**	**189.23**	**1.21**	**197.30**
Public	CIL	37.28	186.07	34.45	202.82	34.69	215.93	38.06	222.96
	SCCL	—	25.65	—	26.77	—	28.73	—	28.94
	JKML	—	0.02	—	0.02	—	0.02	—	0.01
	DVC	—	0.29	—	0.23	—	0.29	—	0.36
	BECML	—	—	—	—	—	—	—	0.71
	BSMDCL	—	—	—	—	—	0.26	—	0.20
	IISCO	0.53	0.51	0.57	0.42	0.55	0.30	0.56	0.16
	Total	**37.81**	**212.54**	**35.02**	**230.25**	**35.25**	**245.54**	**38.62**	**253.34**
Private	TISCO	4.16	—	4.90	—	5.30	—	5.23	—
All India		**41.97**	**212.54**	**39.91**	**230.25**	**40.54**	**245.54**	**43.84**	**253.33**

BCCL - Bharat Coking Coal Ltd
BECML - Bengal Emta Coal Mines Ltd
BSMDCL - Bihar State Mineral Development Corporation Ltd
CCL - Central Coalfields Ltd
CIL - Coal India Ltd
DVC - Damodar Valley Corporation
ECL - Eastern Coalfields Ltd
IISCO - Indian Iron and Steel Company Ltd
JKML - Jammu and Kashmir Minerals Ltd
MCL - Mahanadi Coalfields Ltd
NCL - Northern Coalfields Ltd
NEC - North Eastern Coalfields
SCCL - Singareni Collieries Company Ltd
SECL - South Eastern Coalfields Ltd
TISCO - Tata Iron and Steel Company Ltd
WCL - Western Coalfields Ltd

Source

CCO 1999. Coal Directory of India 1997/98 Calcutta. Coal Controller's Organization, Ministry of Coal

Table 9

Lignite production, power generation, urea, and coke production: 1992/93 to 1999/2000

Year	Lignite (million tonnes)	Power generation (million tonnes)	Urea (tonnes)	Coke (tonnes)
1992/93				
Target	13.30	8358.00	129200	262000
Actual	13.31	8324.12	108591	172606
1993/94				
Target	14.50	9923.00	129000	262000
Actual	14.15	9396.42	111018	226998
1994/95				
Target	15.00	10457.00	122400	240000
Actual	14.41	10893.00	105543	240878
1995/96				
Target	15.50	10640.00	122400	240000
Actual	17.21	12267.67	104560	249140
1996/97				
Target	16.00	10685.00	124000	240000
Actual	17.35	12704.56	119049	215172
* **1997/98**				
Target	16.50	11365.00	124000	240000
Actual	18.10	13402.27	102690	233963
† **1998/99**				
Target	17.50	11715.00	105000	240000
Actual	11.86	8798.17	30491	128005
1999/2000				
Target	17.50	12431.00	96000	240000

* provisional

† up to November 1998

Source

MoC 1999 Annual Report 1998/99. New Delhi: Ministry of Coal

Table 10

Import of coking and non-coking coal (million tonnes): 1991/92 to 1997/98

Year	Coking coal	Non-coking coal	Total
1991/92	5.27	0.66	5.93
1992/93	6.32	0.42	6.74
1993/94	6.82	0.57	7.39
1994/95	10.15	1.24	11.39
1995/96	9.37	3.14	12.51
1996/97	9.78	4.53	14.31
* 1997/98	10.65	6.56	17.21

* provisional

Source

MoC. 1999. Annual Report 1998/99. New Delhi: Ministry of Coal.

Table 11

Allotted captive mining blocks: March 1997

Thermal power station/ company	*Captive block*	*Estimated coal reserves (million tonnes)*	*Estimated production potential (million tonnes a year)*
Power sector			
RPG/CESC - Budge Budge	Sarisathali	60 (mineable)	3.0
RPG - Chandil	South Dhadhu	60 (mineable)	2.0
RPG - Dholpur	Mahan	75 (mineable)	2.5
KPC - Duburi	Utkal-A	200 (geological)	2.5
NDIL - Bhadravati	Lohara W Baranj(IIV) and Bander	286 (geological)	4.5
APSEB - Krishnapatnam I	Gopalprasad	240 (mineable)	10.8
APSEB - Vishakhapatnam II	West II		
TNEB	Gopalprasad W I	240 (mineable)	8.0
INDALCO - Hirakud	Talabira I	17 (geological)	0.5
DCL - Sagardighi	Chuperbhita	289 (geological)	5.0
ACC - Wadi	Lohara East	14 (mineable)	0.3
HOKI - Hospet	Utkal B 1(since withdrawn)	200 (geological)	2.0
WBSEB - Bandel and Santaldih	Tara East	40 (mineable)	1.2
Videocon - N. Chennai II	Utkal B 1	200 (geological)	5.0
Jindal Strips - Raigarh	Gare Pelma	100 (geological)	1.0
Iron and steel			
Jindal Strips Ltd	Gare block–sub-block IV/I	–	–
Prakash Industries	Hasdev–Avand	–	–
Birla Technical Service Ltd	Pakribarwadih	–	–
Steel Authority of India Ltd	Seetanala, Tasra, Parbatpur and Mahal	–	–
Monnet Ispat Ltd	Gare block–sub-block IV/5	–	–
Cement			
ACC Ltd	Bisrar	–	–
J K Corporation Ltd	Gare-Palma IV/8	–	–

ACC - Associated Cement Company Ltd
APSEB - Andhra Pradesh State Electricity Board
CESC - Calcutta Electric Supply Company
DCL - Development Consultants Ltd
INDALCO - Indian Aluminium Company Ltd
KPC - Karnataka Power Corporation
NDIL - Nippon Denro Ispat Ltd
RPG - Reliance Power Group
TNEB - Tamil Nadu Electricity Board
WBSEB - West Bengal State Electricity Board

Source
MoC 1998. New Delhi Ministry of Coal

Table 12

OMS (output per man-shift) in opencast and underground mining (tonnes): 1975/76 to 1998/99

Companies	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99* *
Overall												
CIL (Coal India Ltd)	0.65	0.70	0.92	1.30	1.40	1.46	1.52	1.60	1.80	1.86	1.93	2.00
SCCL (Singareni Collieries Company Limited)	0.69	0.70	0.92	0.96	0.98	1.04	1.05	1.10	1.20	1.19	1.31	1.30
Opencast												
CIL	0.9	1.50	2.24	3.31	3.70	3.80	4.00	4.40	4.70	5.10	5.10	5.50
SCCL	—	—	3.54	4.74	4.48	4.46	4.38	3.60	3.70	3.00	3.50	5.70
Underground												
CIL	0.6	0.50	0.53	0.53	0.53	0.55	0.55	0.60	0.60	0.60	0.60	0.60
SCCL	—	—	0.87	0.65	0.67	0.70	0.71	0.70	0.70	0.70	0.80	0.70

* April–December

Note
The OMS of the SCCL is worked out on the CIL formula w.e.f. 1987/88.

Source
MoC. 1999. Annual Report 1998/99. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ Section: [Coal (general, production, and despatch)]

Table 13

Categorization of coal and coke

Class	*Grade*	*Properties*
Non-coking coal produced in all states other than Assam, Arunachal Pradesh, Meghalaya, and Nagaland	A	UHV greater than 6200 kcal/kg
	B	UHV 5600–6200 kcal/kg
	C	UHV 4940–5600 kcal/kg
	D	UHV 4200–4940 kcal/kg
	E	UHV 3360–4200 kcal/kg
	F	UHV 2400–3360 kcal/kg
	G	UHV 1300–2400 kcal/kg
Non-coking coal produced in the states of Arunachal Pradesh, Assam, Meghalaya, and Nagaland	Not graded	–
Coking coal		
Steel	I	Ash content not exceeding 15%
Steel	II	Ash content greater than 15% but less than18%
Washery	I	Ash content greater than 18% but less than 21%
Washery	II	Ash content greater than 21% but less than 24%
Washery	III	Ash content greater than 24% but less than 28%
Washery	IV	Ash content greater than 28% but less than 35%
Semi-coking and weakly coking coals		
Semi-coking	I	Ash plus moisture content not exceeding 19%
Semi-coking	II	Ash plus moisture content greater than19% but not exceeding 24%
Long-flame coal produced in collieries in all the states excepting Assam, Arunachal Pradesh, Meghalaya, Nagaland, and the Singareni collieries in Andhra Pradesh	A	UHV greater than 6200 kcal/kg
	B	UHV greater than 5600 kcal/kg but not exceeding 6200 kcal/kg
	C	UHV greater than 4940 kcal/kg but not exceeding 5600 kcal/kg
	D	UHV greater than 4200 kcal/kg but not exceeding 4940 kcal/kg
Hard coke		
By-product	Premium	Ash content not exceeding 25%
By-product	Ordinary	Ash content greater than 25% but not exceeding 30%
Beehive	Premium	Ash content not exceeding 27%
Beehive	Superior	Ash content greater than 27% but not exceeding 31%
Beehive	Ordinary	Ash content greater than 31% but not exceeding 36%

UHV - useful heat value

Notes

1. Coking coals have been classified thus by the erstwhile Coal Board under the Coal Mines (Conservation, Safety, and Development) Act, 1952 (12 of 1952) (since repealed) or such coals as have been declared or may be declared as coking coal by the central government under the Colliery Control Order, 1945, or the Coal Mines (Conservation and Development) Act, 1974 (28 of 1974), and the rules made under both the aforesaid Acts.
2. Semi-coking coals and weakly-coking coals are classified as 'blendable coals' by the erstwhile Coal Board under the Coal Mines (Conservation, Safety, and Development) Act, 1952 (12 of 1952) (since repealed), or as may be declared as 'semi-coking' or 'weakly coking' coals by the central government under the Colliery Control Order, 1945, or the Coal Mines (Conservation and Development) Act 1974 (28 of 1974), and the rules made under both the aforesaid Acts.

3 Coals other than coking, semi-coking, or weakly-coking coals are non-coking coals

4 UHV is defined by the formula UHV in kcal/kg is (8900 – 138 x [percentage of ash content + percentage of moisture content]) In the case of coal having moisture less than 2% and volatile content less than 19%, the UHV shall be the value arrived as above, reduced by 150 kcal/kg for each 1% reduction in volatile content below 19% fraction pro-rata Both moisture and ash shall be determined after equilibrating at 60% relative humidity and 40 °C temperature as per relevant clauses of the Indian Standard Specification No IS 1350-1959

5 Ash percentage of coking coals and hard coke shall be determined after air-drying as per IS·1350-1959. If the moisture so determined is more than 2%, the determination shall be after equilibrating at 60% relative humidity at 40 °C as per IS.1350-1959.

6 Long-flame coals shall be defined by the parameters as laid down in Table II of the Indian Standard Specification No IS:770-1964, 'General classification of coals (Revised)'. The volatile matter (on unit coal basis) present in these coals exceeds 32%

7 The above classification shall not apply to coals other than bituminous or sub-bituminous coals as specified under the Indian Standard Specification No. IS·77-1964.

Source

MoC 1995 The Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii), No 718. pp 3–4. New Delhi. Ministry of Coal 5 pp.

Table 14

Comparison of GCV (gross calorific value) and UHV (useful heat value) for non-coking coal (with six per cent moisture content)

Grade	*UHV (kcal/kg)*		*Ash (%)*		*GCV (kcal/kg)*	
	From	*To*	*From*	*To*	*From*	*To*
A	—	>6200	—	<13.56	—	>6406
B	5600	6200	13.56	17.91	5997	6406
C	4940	5600	17.91	22.69	5447	5997
D	4200	4940	22.69	28.06	5042	5447
E	3360	4200	28.06	34.14	4469	5042
F	2400	3360	34.14	41.10	3814	4469
G	1300	2400	41.10	49.07	3064	3814

Source
TERI. 1997. Relative economics of fuels in power generation. TERI Report. New Delhi Tata Energy Research Institute.

Table 15

Quality of coal from Raniganj and Jharia coalfields

Characteristics	*Raniganj coalfield*		*Jharia coalfield*	
	Medium coking	*Semi coking*	*Prime coking*	*Medium coking*
Heating value (MJ/kg)	35.3–37.1	34.0–35.6	35.3–37.2	35.3–37.2
Volatiles (%)	25.0–36.0	39.0–44.0	22.0–35.0	17.0–40.0
Moisture (%)	0.8–2.0	2.5–3.5	0.6–2.0	0.6–2.2
Ash (%)	15.0–25.0	15.0–20.0	15.0–25.0	18.0–35.0
Sulphur (%)	0.5–0.7	0.5–0.7	0.5–0.7	0.5–0.8

Source
CIL.1993 Coal Atlas of India. Calcutta: Coal India Limited.

Table 16

Production from coal washeries (million tonnes): 1975/76 to 1997/98

Feed and production	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *
Prime coking coal											
Raw coal feed	10.9	10.4	9.0	12.5	12.6	12.1	13.0	13.3	13.1	12.8	—
Clean coal production	7.6	7.1	5.3	6.4	6.8	6.5	6.7	6.9	6.8	5.9	4.5
Middling production	2.7	2.5	2.3	3.1	3.5	3.5	3.7	3.5	4.0	3.7	—
Medium coking coal											
Raw coal feed	5.2	7.3	9.7	8.0	9.2	10.4	9.7	9.4	9.9	9.4	—
Clean coal production	3.8	4.5	5.6	4.7	5.2	5.6	5.4	4.9	5.1	5.0	5.4
Middling production	1.2	1.8	2.8	2.5	2.6	3.0	2.9	2.8	2.8	3.1	—
Total											
Raw coal feed	**16.1**	**17.7**	**18.7**	**20.5**	**21.8**	**22.5**	**22.7**	**22.7**	**23.0**	**22.2**	**22.0**
Clean coal production	**11.4**	**11.6**	**10.9**	**11.1**	**12.0**	**12.1**	**12.1**	**11.8**	**11.9**	**10.9**	**10.0**
Middling production	**3.9**	**4.3**	**5.1**	**5.6**	**6.1**	**6.5**	**6.6**	**6.3**	**6.8**	**6.8**	**7.5**

* provisional

Sources

1. CCO. Coal Directory of India (various issues). Calcutta: Coal Controller's Organization, Ministry of Coal.
2. MoC. 1998. Annual Report 1997/98. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ [Section: Coal (general, production, and despatch)]

Table 17

Raw coal feed (million tonnes) and clean coal production (million tonnes) of washeries· 1993/94 to 1997/98

Company/	Raw coal feed					Clean coal production				
Washeries	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Bharat Coking Coal Ltd										
Dugda–I	1.14	1 09	0 85	0 53	0 01	0 54	0 51	0 48	0 26	—
Dugda–II	1 25	1.25	1 10	1 10	1 22	0 60	0 59	0 62	0 48	0 48
Bhojudih	1 51	1 61	1 49	1.45	1 49	0 98	1 01	0.98	0.86	0.83
Patherdih	0 93	1 01	1 02	0 98	0 81	0 52	0 62	0 65	0 55	0 34
Lodna	0 37	0 34	0 34	0 28	0.25	0 20	0 19	0 18	0 14	0 11
Sudamdih	0 85	1 02	0 94	0 90	0 84	0 34	0 47	0 42	0 39	0 33
Barora	0 32	0 33	0 32	0 34	0 36	0.12	0 13	0 15	0 14	0 14
Moonidih	1 05	1.07	0 99	0 98	1 03	0 51	0 55	0 50	0 49	0 51
Mohuda	0 36	0 34	0 35	0 37	0 37	0 26	0 24	0.24	0 24	0 25
Total	**7.78**	**8.06**	**7.40**	**6.93**	**6.38**	**4.07**	**4.31**	**4.22**	**3.55**	**3.00**
Central Coalfields Ltd						—	—	—	—	—
Kargali	2 44	2 18	2 04	1 94	1 72	1 35	1 05	1 01	1 02	0 79
Kathara	1 83	1 76	1 73	1.55	1 62	0 82	0 78	0 72	0 61	0 55
Swang	0 99	0 99	0 97	0 81	0 71	0 70	0 60	0.61	0.46	0.41
Gidi	1 80	1 79	1.95	1 64	1 79	0 96	0 92	0 93	0 68	0 62
Rajrappa	1.71	1 70	2 18	2 42	2 13	0 97	0 90	1 23	1 39	1 01
Kedla	—	—	—	0 01	0 62	—	—	—	0 00	0 25
Total	**8.77**	**8.42**	**8.87**	**8.37**	**8.59**	**4.80**	**4.24**	**4.50**	**4.15**	**3.63**
Western Coalfields Ltd						—	—	—	—	—
Nandan	0 61	0.68	0 69	0 65	0 68	0 37	0 39	0 42	0 41	0 39
Coal India Ltd	17 16	17 16	16 96	15 95	15 65	9 24	8 94	9.14	8 11	7 02
Durgapur Steel Plant						—	—	—	—	—
Durgapur Steel Plant Washery	0 47	0 41	0 24	0 12	0 14	0 30	0 27	0 19	0 09	0 10
Durgapur Power Limited						—	—	—	—	—
Durgapur Power Limited Washery	0 01	0 01	—	—	—	0 01	0 01	—	—	—
Indian Iron and Steel Company						—	—	—	—	—
Chasnala	1 16	1 11	1 00	0 85	1.03	0 59	0 58	0 54	0 50	0 58
Total	**1.64**	**1.53**	**1.24**	**0.97**	**1.17**	**0.90**	**0.85**	**0.73**	**0.59**	**0.68**
Public	18 80	18 69	18 20	16 92	16 85	10 13	9 79	9 87	8 70	7 70
Tata Iron and Steel Company						—	—	—	—	—
West Bokaro–I	0 61	0 51	—	—	—	0 34	0 29	—	—	—
West Bokaro–II	1 90	1 78	1 72	1 82	1 87	0 72	0 67	0 62	0 66	0 69
West Bokaro–III	—	0 43	1 81	2 13	2 07	—	0 16	0 63	0 75	0 74
Jamadoba	1 38	1 33	1 27	1.36	1 24	0 93	0 84	0.80	0 78	0 88
Total	**3.89**	**4.05**	**4.80**	**5.31**	**5.18**	1 99	1 96	2 05	2 19	2 31
Grand total	**22.69**	**22.74**	**23.00**	**22.23**	**22.00**	**12.12**	**11.75**	**11.92**	**10.89**	**10.01**

Source

CCO Coal Directory of India (various issues). Calcutta Coal Controller's Organization, Ministry of Coal

Table 18

Inter-modal split of coal movement

Mode	1977/78 (million tonnes)	%	1995/96 (million tonnes)	%	1996/97 (million tonnes)	%	1997/98 (million tonnes)	%	1998/99 * (million tonnes)	%
Rail	78	78	156	56	165	57	176	58	108	57
Road	17	17	54	19	52	18	53	17	32	17
Belt	2	2	6	2	6	2	7	2	7	4
Ropeway	1	1	6	2	5	2	6	2	4	2
Merry-go-round	2	2	56	21	59	21	63	21	39	21
Total	**100**	**100**	**280**	**100**	**287**	**100**	**305**	**100**	**190**	**100**

* April–November

Source

MoC 1999. Annual Report 1998/99 New Delhi: Ministry of Coal.

Table 19

Capacity and traffic handled at major ports (million tonnes): 1996/97

Port	Capacity		Traffic handled	
	All commodity	*Only coal*	*All commodity*	*Only coal*
Calcutta	8.0	–	6.0	–
Chennai	26.0	–	32.0	7.0
Haldia	18.0	5.0	17.0	7.0
J L. Nehru	10.0	–	8.0	–
Kandla	24.0	–	34.0	0.1
Kochi	13.0	–	12.0	0.1
Mormugao	19.0	–	17.0	0.1
Mumbai	31.0	–	34.0	–
New Mangalore	16.0	–	12.0	–
Paradip	11.0	–	12.0	6.0
Tuticorin	8.0	4.0	9.0	5.0
Vishakapatnam	31.0	–	34.0	9.0

Source

MoST. 1998 Basic Port Statistics of India 1996/97 New Delhi Ministry of Surface Transport.

Table 20

Coal demand for thermal power generation utilities by distance (million tonnes)

Distance (km)	*1994/95*	*1996/97*	*1997/98*
Up to 200	91.1 (54)	103.8 (55)	–
200–500	12.3 (7)	12.8 (7)	–
500–1000	16.0 (10)	15.9 (9)	–
>1000	48.4 (29)	55.0 (29)	100 (37)
Total	**167.8 (100)**	**187.5 (100)**	–

Note

Figures in parentheses are percentages

Source

MoC 1998 Report of the Working Group on Coal and Lignite. New Delhi Ministry of Coal

Table 21

Average cost of (rupees per tonne) production of the CIL (Coal India Limited) and the SCCL (Singareni Collieries Company Limited) coal: 1993/94 to 1997/98

Year	*Average cost of production*	
	CIL	*SCCL*
1993/94	364.35	487.00
1994/95	380.45	543.00
1995/96	412.66	643.00
1996/97	442.06	731.56
1997/98	480.81	775.78

Source

MoC. 1999. Annual Report 1998/99. New Delhi: Ministry of Coal

Table 22

Average pithead unit value (rupees per tonne) of coal: 1974/75 to 1997/98

Year	*Pithead unit value*
1974/75	70.4
1979/80	119.0
1984/85	206.9
1989/90	278.5
1990/91	277 9
1991/92	354.9
1992/93	355.4
1993/94	433.2
1994/95	442.0
1995/96	505.5
1996/97	576.0
1997/98	600.3

Note

The figures are up to March for all the years.

Source

CCO Coal Directory of India (various issues). Calcutta: Coal Controller's Organization, Ministry of Coal

Table 23

Average pithead prices (rupees per tonne) of the CIL (Coal India Limited) and the SCCL (Singareni Collieries Company Limited) coal: 1991 to 1998

Date of revision	Average pithead price	
	CIL	*SCCL*
27 December 1991	322.00	388.00
17 February 1993	364.00	434.00
19 June 1993	381.00	452.00
01 April 1994	381.00	482.00
17 June 1994	401.00	503.00
01 April 1996	469.00	503.00
19 April 1996	469.00	530.00
20 October 1996	498.54	530.00
12 November 1996	498.54	529.42
19 March 1997	498.54	710.59
01 April 1997	553.37	710.59
01 October 1997	559.02	710.59
21 August 1998	585.19	—
29 August 1998	—	753 31

Source

MoC. 1999 Annual Report 1998/99. New Delhi. Ministry of Coal

Table 24

Price build-up (rupees per tonne) for domestic run-of-mine coal from Talcher coalfield

Components	Grade						
	A	*B*	*C*	*D*	*E*	*F*	*G*
Pithead price	828.00	753.00	621.00	510 00	406.00	325.00	233 00
Internal transport charges	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Sizing charges	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Royalty	135.00	135.00	95 00	70.00	70.00	50.00	50.00
Stowing excise duty	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Central sales tax (@4%)	40.70	37.30	30.42	24.98	20.82	16.78	13.10
Total	**1058.20**	**969.80**	**790.92**	**649.48**	**541.32**	**436.28**	**340.60**

Source

CIL 1998 Price list (October 1997) and other documents. New Delhi. Coal India Limited.

Table 25

Annual average import price of coal (dollars per tonne)

Country	*1994*	*1995*	*1996*	*1997* *
Australia	32 30	39.37	38.07	35 40
US	36 48	39 19	37.21	36.50

* January–December

Note

Coal (Australian), thermal, 12 000 btu/lb, less than 1% sulphur, 14% ash, free on board piers, Newcastle/Port Kembla

Coal (US), thermal, 12 000 btu/lb, less than 1% sulphur, 12% ash, f.o.b. piers, Hampton Road/Norfolk

Table 26

Customs duty structure on imported coal

Import of coal	*Current duty*
Coking coal of ash content less than 12%	3% basic customs duty
Special customs duty	5%
Special additional duty	4%
Non-coking coal, coke, coking coal of ash content above 12%	10% basic customs duty
Special customs duty	5%
Special additional duty	4%

Source
MoC. 1999 Annual Report 1998/99 New Delhi: Ministry of Coal

Table 27

Royalty (million rupees) paid on coal by states. 1991/92 to 1997/98

Year	*West Bengal*	*Bihar*	*Orissa*	*Maharashtra*	*Madhya Pradesh*	*Uttar Pradesh*	*Assam*	*Andhra Pradesh*	***Total***
1991/92	100.1	3178.0	434.7	610.4	2402.0	474.9	6.4	354.2	**7560.7**
1992/93	87.2	5043.1	631.4	1088.6	3845.2	667.6	5.4	1000.0	**12368.5**
1993/94	106.3	5550.5	728.2	1110.9	3695.6	705.9	4.4	2913.0	**14814.8**
1994/95	95.9	6130.5	1040.8	1597.0	4389.1	873.9	4.2	1445.3	**15576.7**
1995/96	78.2	6583.3	1807.9	2179.0	6667.7	1135.0	215.9	1752.8	**20419.8**
1996/97	108.7	6827.7	1853.8	2002.9	6841.4	1214.1	99.2	1971.4	**20919.2**
1997/98	126.4	6589.5	2275.9	2047.9	6636.3	1023.5	61.1	2781.1	**21541.7**

Source
MoC. 1999. Annual Report 1998/99 New Delhi Ministry of Coal

Table 28

Revised rates of royalty (rupees per tonne)

Coal group	*Royalty w e f 1 August 1991*	*Royalty w e f. 11 October 1994*
Group-I (Coking coal SG I II, WG I	150	195
Group-II (Coking coal WGII, III, SC I II Non-coking A, B)	120	135
Group-III (Coking coal WGIV, Non-coking C)	75	95
Group-IV (Non-coking D, E)	45	70
Group-V (Non-coking F, G)	25	50
Group-VI (Coal produced in Andhra Pradesh)	70	75

Source
MoC 1999 Annual Report 1998/99 New Delhi: Ministry of Coal

Table 29

Selling price of coal in respect of the CIL (Coal India Ltd) and subsidiaries (rupees per tonne): 5 January 1999

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
Non-coking coal					
Eastern Coalfields Ltd (Ranigunj)	Coal produced in Annexure I collieries	A	1246	1191	1180
Coal produced in other collieries of Ranigunj Coalfields		B	1181	1126	1115
		C	1016	961	950
		D	830	776	770
	Long-flame coal	A	1133	1083	1073
		B	1074	1024	1014
		C	925	875	865
		D	760	706	700
	Non-long-flame coal	A	1066	1016	1006
		B	1008	958	948
		C	859	809	799
		D	696	642	636
		E	465	451	445
		F	375	361	355
		G	274	260	254
Eastern Coalfields Ltd (Salanpur)	Non-long-flame coal	A	1060	1010	1000
		B	960	910	900
		C	800	750	740
		D	650	596	590
		E	465	451	445
		F	375	361	355
		G	274	260	254
Eastern Coalfields Ltd (SP Mines)	Coal produced in Annexure I collieries	A	1187	1132	1121
		B	1080	1025	1014
		C	912	857	846
		D	748	694	688
Eastern Coalfields Ltd (SP Mines and Mugma)	Long-flame coal	A	1079	1029	1019
		B	982	932	922
		C	830	780	770
		D	685	631	625
	Non-long-flame coal	A	1012	962	952
		B	916	866	856
		C	764	714	704
		D	621	567	561
		E	465	451	445
		F	375	361	355
		G	274	260	254
Eastern Coalfields Ltd (Rajmahal Project)	Long-flame coal	D	838	784	778
	Non-long-flame coal	E	618	604	598
		F	528	514	508
		G	427	413	407
Western Coalfields Ltd	Long-flame coal	A	1096	1046	1036
		B	1038	988	978
		C	974	924	914
		D	923	869	863
	Non-flame coal	A	1033	983	973
		B	975	925	915
		C	912	862	852
		D	859	805	799
		E	685	671	665
		F	574	560	554
		G	438	424	418
Central Coalfields Ltd and South–Eastern Coalfields Ltd Bharat Coking Coal Ltd and Northern Coalfields	Coal produced in Annexure I collieries	A	1134	1079	1068
		B	1032	971	966
		C	872	817	806
		D	748	694	688
	Long-flame coal	A	1030	980	970
		B	938	888	878
		C	793	743	733
		D	685	631	625

(contd)

Table 29 contd

Selling price of coal in respect of the CIL and subsidiaries (rupees per tonne): 5 January 1999

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
	Non-long-flame coal	A	967	917	907
		B	875	825	815
		C	730	680	670
		D	621	567	561
		E	465	451	445
		F	375	361	355
		G	274	260	254
Mahanadi Coalfields Ltd	Long-flame coal	A	992	942	932
		B	903	853	843
		C	765	715	705
		D	663	609	603
	Non-long-flame coal	A	929	879	869
		B	840	790	780
		C	702	652	642
		D	599	545	539
		E	448	434	428
		F	361	347	341
		G	263	249	243
Coking coal	Steel	I	1717	1667	1657
Bharat Coking Coal Ltd	Steel	II	1444	1394	1384
(For collieries listed in Annexure III)	Washery	I	1259	1209	1199
	Washery	II	1053	1003	993
	Washery	III	794	744	734
	Washery	IV	743	693	683
Bharat Coking Coal Ltd	Steel	I	1601	1551	1541
	Steel	II	1347	1297	1287
	Washery	I	1175	1125	1115
	Washery	II	984	934	924
	Washery	III	743	693	683
	Washery	IV	695	645	635
Eastern Coalfields Ltd	Washery	I	1175	1125	1115
	Washery	II	984	934	924
	Washery	III	743	693	683
	Washery	IV	695	645	635
Central Coalfields Ltd	Washery	I	1135	1085	1075
	Washery	II	950	900	890
	Washery	III	718	668	658
	Washery	IV	673	623	613
South Eastern Coalfields Ltd	Washery	I	1084	1034	1024
	Washery	II	908	858	848
	Washery	III	687	637	627
	Washery	IV	644	594	584
Western Coalfields Ltd	Washery	I	1084	1034	1024
	Washery	II	908	858	848
	Washery	III	825	775	765
	Washery	IV	688	638	628
Semi-coking and weakly-coking coal					
Bharat Coking Coal Ltd and Eastern Coalfields Ltd					
(In Annexure III collieries)	Semi-coking	I	1216	1166	1156
	Semi-coking	II	1017	967	957
Bharat Coking Coal Ltd and	Semi-coking	I	1135	1085	1075
Central Coalfields Ltd	Semi-coking	II	950	900	890
All subsidiaries	Semi-coking	I	1084	1034	1024
	Semi-coking	II	908	858	848

Source

CIL S&M 1999 Price list January 1999 New Delhi Coal India Limited

Table 30

Plan expenditure and the share of coal (million rupees)

Plan	Plan expenditure ‡	Share of coal	Total energy *
First (1951–56)	19600	0	3861 2 (19.7)
Second (1956–61)	26700	507 3 (1.9)	3310 8 (12.4)
Third (1961–66)	85800	1115.4 (1.3)	15873.0 (18.5)
Fourth (1969–74)	157800	1104.6 (0.7)	33453 6 (21.2)
Fifth (1974–79)	394300	11434.7 (2 9)	99363.6 (25.2)
Sixth (1980–85)	1092900	38251.5 (3.5)	307104.9 (28.1)
Seventh (1985–90)	2202200	70470.4 (3.2)	621020 4 (28 2)
† Eighth (1992–97)	4341000	104184.0 (2.4)	1150365 0 (26.5)

Figures in parentheses are percentages

* total energy includes power, coal, oil and gas, and new and renewable energy sources
† outlay
expenditure at current price at the base year of the respective plans

Source
Planning Commission 1999 Ninth Five-Year Plan. 1997–2002 Volume II Thematic Issues and Sectoral Programmes. New Delhi Planning Commission, Government of India

Table 31

Annual Plan expenditure during the Eighth Five-Year Plan and actual expenditure (million rupees)

Year	Coal India Ltd	Singareni Collieries Company Ltd	Science and technology regional exploration and others
1992/93			
Budget estimate	18500.00	4090 00	230 00
Revised	17600.00	4090 00	230.00
Actual	18084 70	4064 50	182.40
1993/94			
Budget estimate	19010.00	6422 00	170.00
Revised	17200.00	5600.00	170.00
Actual	16879 20	5449 80	159.10
1994/95			
Budget estimate	20629 00	4834 00	235 00
Revised	18500 00	5500 00	229 90
Actual	16045.60	5165 80	48 40
1995/96			
Budget estimate	22600 00	5160 00	438 20
Revised	12037.80	3357.50	251 00
Actual	15036 30	2593.50	147 90
1996/97			
Budget estimate	21430 00	5389 70	528.00
Revised	13108 30	3250 00	280 00
Actual	15304 50	2500.60	280 70

Source
MoC 1999 Annual Report 1998/99 New Delhi Ministry of Coal

Table 32

Net budgetary support as percentage of actual plan expenditure in coal

Year	Net budgetary support (%)
1992/93	13.54
1993/94	8 50
1994/95	12 55
1995/96	12.59
1996/97	7.33

Source
MoC 1999 Annual Report 1998/99 New Delhi Ministry of Co

Table 33

Availability and estimated sectorwise consumption of raw coal (million tonnes): 1975/76 to 1997/98

Items	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Availability											
Production	99.7	114.0	154.3	213.9	232.8	242.0	248.7	257.8	273.4	286.1	297.2
Imports **	—	0.6	2.0	5.7	5.9	6.3	7.1	8.3	8.9	9.5	9.5
Exports	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pithead stock (opening)	7.6	14.0	30.2	37.6	42.5	48.5	51.4	50.8	47.5	45.6	42.0
Pithead stock (closing)	11.9	18.3	29.0	42.5	48.5	51.3	50.8	47.5	45.6	42.0	41.5
Adjustment of pithead stock	·										
Industrial stock (opening)	3.8	2.3	4.9	6.2	5.3	5.5	—	—	—	—	—
Industrial stock (closing)	6.5	3.1	6.8	5.3	5.5	—	—	—	—	—	—
Available for industrial consumption after adjustment of off-take	92.1	109.4	155.5	213.3	228.9	241.8	255.9	269.2	284.0	299.0	307.1
Consumption/supply (raw coal)											
Steel and washery	18.9	21.0	24.8	30.9	34.0	37.3	37.6	38.6	39.1	39.8	39.8
Railways	14.3	11.8	9.6	5.2	5.1	4.3	2.0	0.7	0.3	0.1	0.1
Electricity (excluding middlings)	23.0	38.2	68.6	113.7	126.8	138.6	154.4	160.9	184.5	199.6	205.5
Cement	4.4	4.8	8.0	10.4	10.8	11.7	11.1	12.4	11.1	10.1	10.1
Cotton	2.2	2.0	2.4	2.6	2.0	1.9	1.8	1.8	1.2	1.3	1.3
Jute	0.2	0.1	0.1	0.1	0.1	—	—	—	0.1	0.1	—
Paper *	1.3	2.1	2.7	2.8	2.7	2.6	2.9	3.2	3.2	3.5	3.4
Brick	3.3	0.4	0.5	1.7	1.8	1.7	1.5	1.0	0.9	1.0	1.6
Coal for soft coke	3.6	2.9	2.3	1.2	1.0	1.0	0.4	0.3	0.3	0.3	—
Other industries	18.1	22.3	32.5	40.6	40.5	38.7	39.5	46.7	40.0	39.8	42.1
Colliery consumption	2.8	3.8	4.0	4.1	4.1	4.0	4.7	3.7	3.5	3.4	3.1
Total consumption	**92.1**	**109.4**	**155.5**	**213.3**	**228.9**	**241.8**	**255.9**	**269.3**	**284.2**	**299.0**	**307.1**

* includes only rail despatches
** only coking coal imports

Source
CCO. Coal Directory of India (various issues). Calcutta: Coal Controller's Organization, Ministry of Coal

Table 34

Supply (thousand tonnes) of coal to steel plants: 1995/96 to 1997/98

	1995/96					1996/97					1997/98				
Steel plants	*Prime coking coal*	*Medium coking coal*	*Blendable coking coal*	*Total*	*Boiler coal*	*Prime coking coal*	*Medium coking coal*	*Blendable coking coal*	*Total*	*Boiler coal*	*Prime coking coal*	*Medium coking coal*	*Blendable coking coal*	*Total*	*Boiler coal*
Bhilai	1088.3	1381.5	239.2	2709	629.9	892.4	1273.2	205	2370.6	779.4	893	1084	165	2142	760
Bokaro	978	992.4	7.8	1978.2	1674.5	900.1	1252.1	0	2153	1602.9	901	1204	0	2105	1483
Durgapur	726.9	548.4	21.1	1296.4	384.4	622	448.6	8.7	1079.3	549.3	532	396	0	928	671
IISCO	900	483.7	66.9	1450.6	195.2	777.1	419.3	73.6	1270	248.1	636	356	42	1034	209
Rourkela	618.5	686.2	8.6	1313.3	1199.3	356.2	714.1	0	1070.3	1302.2	344	570	0	914	1364
Total SAIL	4311.7	4092.2	343.6	8747.5	4083.3	3547.8	4108.1	287.3	7943.2	4481.9	3306	3610	207	7123	4487
TISCO	681.6	1172.9	46.9	1901.4	635.8	378	590	17	985	1474.2	900	1427	3	2330	1450
VSP	20.9	915.8	0	936.7	1194.4	75.7	750.5	0	826.2	1351.8	0	6.9	0	619	1434
Grand total	**5014.2**	**618.9**	**390.5**	**11585.6**	**5913.5**	**4001.5**	**5448.6**	**304.3**	**9754.4**	**7307.9**	**4206**	**5656**	**210**	**10072**	**7371**

IISCO - Indian Iron and Steel Company, SAIL - Steel Authority of India Ltd, TISCO - Tata Iron and Steel Company Ltd, VSP - Visakhapatnam Steel Plant

Source
CCO. 1999 Coal Directory of India 1997/98 Calcutta Coal Controller's Organization, Ministry of Coal

Table 35

Coal supplied (million tonnes) from the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) to various consumers. April–December 1998/99

	CIL			SCCL		
Sector	*Target offtake*	*Actual offtake*	*Supply (%) against target*	*Target offtake*	*Actual offtake*	*Supply (%) against target*
Power	143.01	133.88	94	15.83	14.09	89.0
Steel	14.84	13.48	91	—	—	—
Locomotive	—	0.02	100	—	—	—
Cement	6.39	3.88	61	2.83	2.16	76.3
Fertilizer	2.93	2.73	93	0.46	0.28	60.9
Others	27.67	27.80	100	3.16	1.88	59.5
Colliery consumption	2.15	1.91	89	0.32	0.20	62.5

Source
MoC 1999. Annual Report 1998/99 New Delhi Ministry of Coal

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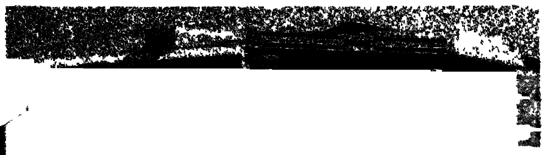

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Oil and gas

Exploration and production

India's balance recoverable reserves[1] of crude oil and natural gas have declined continuously after peaking at 806 MT (million tonnes) and 735 BCM (billion cubic metres), respectively, in 1991 and 1992 (Figure 1).

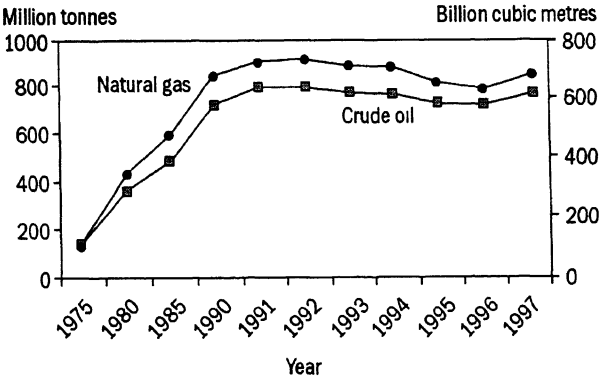

Figure 1 Proven balance recoverable reserves of crude oil and natural gas
Source MoPNG (1999)

Of the 26 sedimentary basins, only 6 have been explored so far, accounting for only 30% of the country's prognosticated reserves. India, therefore, continues to be one of the least explored regions with a well density of a mere 20 per 10 000 square kilometres as against a world average of 100.

The ONGC (Oil and Natural Gas Corporation) Limited and the OIL (Oil India Limited) expanded their drilling activities in 1981/82 to explore new areas. Since then, there has been an increase in drilling activities in the offshore areas, representing a rationalization of exploratory activities in line with the prognostication of reserves. This is also evident from the number of wells drilled as well as the metreage drilled (Table 2). However, the current reserve accretion continues to be low and this has been identified as a major area of concern.[1]

New Exploration Licensing Policy

The poor reserve accretion during the first three years of the Eighth Five-Year Plan (1992–97) led the government to launch the Accelerated Programme for Exploration. The programme aimed at developing a national seismic grid and exploration in the frontier areas and deep waters. The Eighth Plan outlay was also suitably enhanced. However, despite these efforts, the reserve accretion targets were not met by the end of the Eighth Plan period. This, among other factors, redirected the attention towards supplementing exploration activities through private sector involvement.

In the ninth bidding round held in 1995, also known as the joint venture rounds, efforts were made to reduce the risk for private investors by associating ONGC/OIL as partners in these ventures. However, the rigid decision-making structures of the NOCs (national oil companies) have reduced the attractiveness of this innovation.

It was also proposed that exploration be prioritized according to the geophysical merit of the basins and not according to their categorization on the degree of success. The new strategy would entail identification of prospects in old fields/ basins (Category I) using new technology and updated databases, and focusing on exploration in western and north-eastern onland basins like the Mesozoic section of Cambay, Kachch, Saurashtra, Rajasthan, and areas of uncertain prospects such as the Deccan plateau.

The result of these efforts, however, led to the award of 35 exploration blocks and 30 discovered fields to the private sector. Work is already in progress in 22 exploration blocks while the contracts for some more blocks are expected to be signed soon. In addition, 5 medium and 13 small fields are under development; some of them already producing oil and gas. So far, the total investment brought into the sector, mostly in the producing fields, exceeds a billion dollars. The crude oil production from these fields has increased over the years (Table I). However, the bulk of the reserve accretion has taken place around the previously discovered fields and no new areas are being explored. A number of reasons can be cited for the disappointing results.

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[1] For more details on the categorization of reserves, see *TEDDY 1998/99* (previous edition).

Table I Crude oil production from small- and medium-sized fields

Year	*Crude production (million tonnes)*
1994/95	0.25
1995/96	0.65
1996/97	1.34
1997/98	2.51
1998/99	3.42

Source Desai (1999)

There was a general perception that the blocks with high prospects were reserved for the NOCs and only the high-risk blocks were offered to the private investors. The seismic data provided was inadequate in some cases, in addition to being old and expensive. The NOCs continued to hold on to the blocks they were awarded on a nomination basis and also played a decisive role in the delineation of the blocks. Even though it had been recommended that, where feasible, an exploration block should include a producing field or an area with oil/gas finds, there were instances where this was not done and the producing areas were deliberately not included in the blocks that were offered for exploration. The delay in awarding the PSCs (production-sharing contracts) was an important reason for the limited success of the exploration policy. In addition, though the PSCs provided for crude oil / gas agreements to be finalized within 90 days, only one such agreement has been signed in the last three to four years. This has led to an ad hoc arrangement to buy and sell oil/gas from these fields, resulting in delayed cost recovery. These factors have significantly reduced the commercial attractiveness of the blocks offered for exploration.

The NELP (New Exploration Licensing Policy) of 1999 seeks to eliminate most of the problems mentioned above. It proposes to change the procedure for new contracts. It does not address the problems associated with the PSCs already issued by the government. Altogether 48 exploration blocks, 26 offshore up to 400 m isobath, 12 deep offshore off the east coast beyond 400 m isobath, and 10 onland blocks have been identified under the NELP. The new policy has an improved fiscal package to offer, which will be welcomed by all the investors. A petroleum tax guide has also been compiled to help the bidders understand the economic and financial implications. Furthermore, the model PSC will reduce the time taken for contract negotiations. Therefore, it can be said that the new policy is a step towards providing a level playing field for the private investors and the NOCs. The NOCs would now have to compete with others for acreage rather than get it through nominations. However, due to lukewarm response from global oil companies, the ONGC may be compelled to work on a large chunk of the blocks either on its own or in a joint venture with 50% equity with GAIL or the IOC. Petronas Malaysia is also expected to team up with the IOC to bid for 2 blocks in the Krishna–Godavari basin.

Some of the positive features of the NELP (1999) are given in Box 1. On the flip side, however, it should be noted that the timing of the launch of the NELP in 1995 was rather inappropriate as the international oil market was depressed at that time.

The current level of crude production is 36 MT and is expected to increase to about 37 MT by 2002 (Planning Commission 1999). In view of the refining capacity addition, about 78 MT of crude oil is expected to be imported by 2002, thereby leading to an increase from 47% to 70% in the import dependency.

There are shortfalls in the availability of natural gas as against the commitments already made. The total gas production in 1997/98 was 26 BCM and is expected to increase to 31 BCM by 2002.

Oil

Refining

The total refining capacity of the 15 refineries in the country at the end of March 1999 was 67.5 MTPA (million tonnes per annum). The refining capacity is expected to go up to 114 MTPA by 2001/02

Box 1 Positive features of the New Exploration Licensing Policy

- There is no carried or participating interest of the NOCs (national oil companies) and, therefore, the profits of the contractor are not further reduced after sharing with the government.
- The NOCs will also bid for the blocks outside the area that has already been allocated to them. The contract will, therefore, be between the company(ies) and the government.
- The exploration period can be of eight years as against seven years in the pre-NELP (New Exploration Licensing Policy) system
- In view of the infrastructure status given to the upstream petroleum sector, the contractor will enjoy an income tax holiday for seven years from the date of commencing commercial production. This is an additional benefit to that already available for exemption from income tax till 100% cost recovery.
- To facilitate the bidders understand the economic and financial implications, a petroleum tax guide has been prepared.
- The evaluation criteria for award of a block has been made more transparent than before.
- A high-level inter-ministerial group has been formulated to expedite the finalizing and signing of production-sharing contracts.

Table II Existing refinery operating capacities and expansions (million tonnes per annum)

Refinery	*1998/ 99*	*1999/ 2000*	*2000/ 01*	*2001/ 02*	*2006/ 07*
BPCL, Mumbai	8.8	9.0	9.0	9.0	9.0
HPCL, Mumbai	5.3	5.9	5.9	5.9	5.9
HPCL, Vizag	3.9	6.0	7.5	7.5	7.5
IOC, Koyali	10.9	10.9	12.5	13.7	13.7
IOC, Mathura	8.9	9.0	9.0	9.0	9.0
IOC, Panipat	2.2	4.3	6.0	6.0	12.0
IOC, Barauni	2.2	3.3	4.2	6.0	6.0
IOC, Haldia	4.7	4.7	4.7	5.0	5.0
IOC, Guwahati	0.8	0.9	1.0	1.0	1.0
IOC, Digboi	0.5	0.6	0.7	0.7	0.7
BRPL	1.7	2.0	2.4	2.4	2.4
Numaligarh	0.0	1.6	3.0	3.0	3.0
MRL, Manali	6.1	6.5	6.5	6.5	9.5
MRL, Narimanam	0.6	0.7	0.7	0.7	1.0
CRL	7.8	7.8	7.8	7.8	10.5
MRPL	4.1	5.0	9.0	9.0	9.0
Total	68.5	78.2	89.9	93.2	105.2

Source TERI Estimates

(Planning Commission 1999) due to additions in refining capacity in PSUs (public sector undertakings), joint ventures, and private sector units, and expansion of existing refineries. The refinery-wise capacity addition during the Ninth Plan period is provided in Table II.

The expected increase in refining capacity would be sufficient to meet the growth in product demand (105 MTPA by the end of the Ninth Plan period) with minimum level of imports.

The refining sector was delicensed in June 1998. In addition, the public sector oil companies were allowed to form joint ventures with an equity participation of 26%.

The Sub-group on Refining has suggested certain financial incentives for the efficient functioning of the refining sector and enhancing private sector participation during the Ninth Plan period. The total indigenous crude production estimated for 1998/99 was 36 MT and about 32 MT of crude was imported. These figures are likely to increase to 37 MT and 78 MT, respectively, in 2001/02, thereby necessitating the development of adequate number of crude pipelines as proposed by the Sub-group, to increase capacity utilization of the existing refineries.

There is also an impending need to reduce fuel losses in refineries, which reached a level of 7.1% in 1985/86 and declined to 6.1% in 1996/97. To reduce energy consumption, projects amounting to 7.2 billion rupees have been identified, which, on implementation, will achieve a saving of 186 000 TPA (tonnes per annum).

Emission standards for refineries

Emissions from refineries account for about seven per cent of the total emissions from the production and consumption of petroleum products. The effluents generated in a refinery can be classified as (1) liquid effluents, (2) gaseous effluents, and (3) oily sludge. Compliance with the prescribed MINAS (minimum national standards) with regard to liquid and gaseous effluents is a statutory requirement. All the refineries in the country are equipped with adequate pollution control facilities, which are upgraded and reviewed from time to time.

The liquid effluents – generated when the water gets contaminated with oil and other pollutant – have to be treated before discharge. The government has prescribed MINAS for liquid effluents with respect to critical parameters such as oil and grease, phenols, sulphides, biochemical oxygen demand, and total suspended solids. These standards specify the quantum of discharge of these pollutants in terms of crude throughput. All the refineries in the country are equipped with full-fledged effluent treatment plants comprising physical, chemical, and biological processes. The treated waste water is reported to meet the standards in all the refineries.

Sulphur dioxide is the primary gaseous effluent, for which the government has prescribed MINAS in terms of sulphur dioxide emissions per tonne of feed processed (Table III). The stipulation for boilers is in terms of minimum stack height to minimize the ground-level concentrations.

Table III Emission standards for sulphur dioxide in refineries

Process	*Emission limit*
Distillation (atmospheric + vacuum)	0.25 kg/MT (kilograms per million tonne) of feed*
Catalytic cracker	2.5 kg/MT of feed*
Sulphur recovery unit	120 kg/MT of sulphur in the feed*

* feed for that part of the process only
Source TERI (1998)

Some of the measures adopted by refineries for controlling sulphur dioxide emissions include (1) the use of low sulphur crude oil; (2) desulphurization of refinery fuel gas; (3) advance process control systems; (4) adoption of energy conservation measures, thereby reducing fuel consumption; and (5) higher stacks for better dispersion of gases.

Refineries have also adopted various techniques, such as installation of improved mixers for reducing the formation of oily sludge in the crude storage tanks and use of chemicals for recovery of oil from the tank bottom sludge. In some refineries like the BPCL (Bharat Petroleum Corporation Limited) and the HPCL (Hindustan Petroleum Corporation Limited), Mumbai, the sludge is sold to micro-crystalline wax manufacturers while in the IOC's refinery at Mathura, the sludge is treated with micro-organisms.

The IOC-Mathura refinery was the first to receive ISO 14001 accreditation in July 1996, followed by other refineries, namely, the IOC set-ups at Guwahati, Barauni, Gujarat, Haldia, and Digboi and the BPCL-Mumbai. In other refineries, efforts are underway to conform to the International Environment Management System (MoPNG 1998).

Product quality

In view of the current environmental standards, the content of harmful chemicals such as lead, benzene, sulphur, and aromatics needs to be reduced. For the production of green or environment-friendly fuels, the cost has been estimated at 65 billion rupees for the existing refineries. The present status with respect to product quality is summarized below.

- Reformers have been introduced throughout the country with effect from 31 December 1996 in refineries to produce low-lead MS (motor spirit). Unleaded MS with a lead content of 0.013 g/litre (maximum) has been introduced in the metro cities of Delhi, Calcutta, Mumbai, and Chennai, and also in the city of Agra and the radial routes with effect from 1 April 1995. Unleaded MS has also been introduced in all the state capitals and union territories in June 1998. It is proposed to introduce unleaded MS throughout the country by 31 March 2000.
- The CPCB (Central Pollution Control Board) allows a maximum of 5% benzene content in the MS. To meet this specification, while maintaining the existing MS production level, imports worth 1.8 billion rupees a year and additional facilities at a cost of 8 billion rupees would be required. It is proposed to reduce the benzene content to three per cent in the metros by 2000. The IOC has already reduced the benzene content to three per cent well ahead of the targeted schedule.
- The BPCL is manufacturing MTBE (methyl tertiary butyl ether) which is used for oxygenating MS. The MTBE facilitates more complete combustion and boosts the octane value.
- The installation of hydrodesulphurization units in refineries is expected to improve the quality of HSD (high speed diesel) by reducing the sulphur content. Low-sulphur HSD with a sulphur content of 0.5% (maximum) has been introduced in the four metro cities of Delhi, Mumbai, Calcutta, and Chennai, and in the environmentally sensitive area of the Taj Trapezium with effect from 1 April 1996. Low-sulphur HSD with a sulphur content of 0.25% was introduced in the Taj Trapezium with effect from 1 September 1996 and efforts are under way to introduce low-sulphur diesel throughout the country. The IOC

has recently constructed diesel desulphurization units in four of its refineries. These units will be retrofitted with second stage reactors for total switch over to ultra low sulphur diesel with sulphur content of 0.05%.

- With the proposed change in the distillation specification, a loss of about 2.5 MTPA in HSD production is estimated, requiring additional imports worth 7 billion rupees a year.
- The cetane number of HSD, which is an indicator of the ignition quality of the fuel, is currently low at a minimum of 42, but efforts are being made to increase it to 48 by 2001/02.

Steps are being taken to improve the quality of fuels used in the industries. The chemical composition of some of these fuels is provided in Table IV.

Table IV Chemical composition of fuels used in industry (%)

Fuel	*Carbon*	*Sulphur*	*Nitrogen*	*Ash*
Fuel oil	84.00	3.50	–	0.5
Light diesel oil	85.00	3.00	–	–
Low sulphur heavy stock	86.70	1 00	–	–
Liquefied petroleum gas	81.50	–	–	–
Natural gas	66.00	–	–	–

Source TPL (undated)

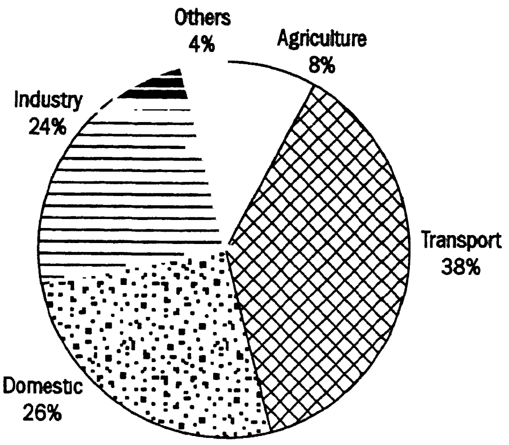

Figure 2 Consumption pattern of petroleum products by sector (1997/98)
Source TERI (1999)

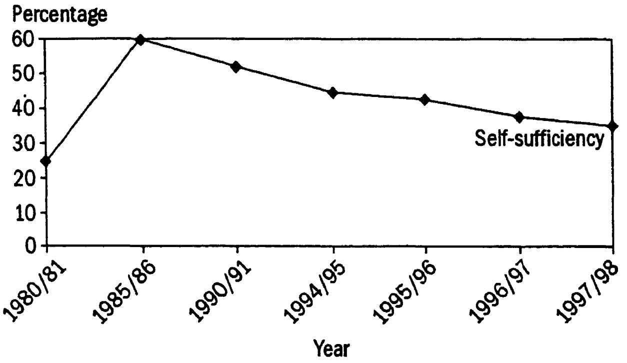

Figure 3 Oil self-sufficiency in India
Source MoPNG (1998a)

Demand and supply

The aggregate consumption of petroleum products during 1997/98 was 85 MT. During 1992–98, LPG (liquefied petroleum gas) and HSD registered the largest demand growth rate of 9.2% and 8.6%, respectively. The largest consumers of petroleum products are the transport, domestic, and industrial sectors (Figure 2).

The total production of petroleum products during 1997/98 was about 65 MT (MoPNG 1999a). The annual production figures can be seen in Table 8. India's self-sufficiency in petroleum products has declined from 60% in 1985/86 to about 34% in 1997/98 (Figure 3). The country's imports in 1998/99 are estimated at 14 MT diesel, 3.5 MT LPG, and 4.5 MT SKO (superior kerosene oil). However, by 2002 there may be a domestic surplus of selected petroleum products, provided the Essar and Bina refineries with a combined capacity of 18 MT are commissioned and the IOC's expansion of Koyali refinery is completed as per schedule. This implies a growth in imports from 2 MT in 1985/86 to about 17 MT in 1998/99.

Transport infrastructure

The present infrastructure is inadequate to meet the growing demand for petroleum products. The new refining capacity needs to be supported by crude pipelines to supply crude to refineries and product pipelines to transport petroleum products to demand centres (Maps 3 and 4, Appendix II).

At present, there are three crude pipelines: one belongs to the OIL and the other two belong to the IOC. The OIL crude pipeline brings north-eastern crude to the Barauni refinery. One IOC crude pipeline takes crude from the Gulf of Kachch to Koyali and Mathura refineries and the other pipeline takes crude from Haldia to the Barauni refinery. It is desirable to augment the Haldia–Barauni crude pipeline with a capacity to handle imported crude, not only for catering to the full capacity of the Barauni refinery (6 MT) but also to supply crude to the Bongaigaon refinery. The latter is being extended to carry crude to IOC's Panipat refinery. The quantity of north-eastern crude is inadequate to meet the capacity of the refineries at Guwahati, Digboi, Numaligarh and Barauni, whose current capacities of 7.3 MT are being expanded to 13 MT by the end of the Ninth Plan. It is, therefore, desirable to augment the Haldia–Barauni crude pipeline with a capacity to handle 8 MT of imported crude not only for catering to the full capacity of 6 MT to the Barauni refinery but also to supply crude to the Bongaigaon refinery.

Another new pipeline is to be laid from the Gulf of Kachch to Bina for meeting the crude requirements of the new joint venture refinery at Bina. The projected joint venture refinery in Bhatinda, Punjab, will need to draw its crude requirement through a new pipeline presently proposed to be laid from the Gulf of Kachch. Crude requirements of the proposed joint venture refinery in Uttar Pradesh may be fed through an extension of the Gulf of Kachch–Bina pipeline. New pipelines need to be planned to meet the envisaged requirements by utilizing the pipeline on a contract-carriage basis. In all, the Sub-group on Refining has proposed 11 new crude pipelines for enhancing the capacity utilization of the existing refineries.

There is considerable scope for improving the energy efficiency of petroleum product transportation system. Currently, the bulk of the movement of petroleum products is through railways, followed by pipelines (Table 13). The movement of products from coastal refineries along the shoreline is a regular feature to position products at pivotal port terminals from where the rail movement is relatively easier. While rail movement has the advantage of using the existing track capacity, it has the limitation of being more energy intensive than pipelines. Product losses are also negligible in the case of pipelines. This not only reduces the need for tankage at the destination but also brings down the inventory carrying cost. It is also possible to provide additional capacity in the pipelines to meet peak requirements more efficiently. Therefore, greater emphasis needs to be laid on developing pipelines as the primary mode of inland movement of petroleum products. The current pipeline capacity is provided in Table V.

Table V Existing product pipeline network

Pipeline	*Capacity (MTPA[1])*	*Length (km)*	*Throughput 1997/98[2] (MTPA)*
Guwahati-Siliguri	0.820	435	1.017
Haldia-Barauni	1.420	525	1.425
Haldia-Maurigram-Rajbandh	1.250	269	1.873
Barauni-Mughalsarai-Allahabad-Panki (Kanpur)	1.800	669	1.748
Koyali-Sabarmati (Ahmedabad)	1.100	116	1.565
Mumbai-Pune	3.850	161	3.850
Mathura-Bijwasan (Delhi) - Ambala-Jalandhar	3.700	513	3.283
Kandla-Sidhpur-Salawas (Jodhpur) -Sanganer (Jaipur)-Rewari-Sangrur-Bhatinda	6.000	1331	5.760
Digboi-Tinsukia	0.406	–	0.406
Mumbai-Manmad	4.000	–	–

[1] million tonnes per annum

[2] Estimate

Source MoPNG (1998a)

The Kandla–Bhatinda pipeline would meet the shortfall of petroleum products in high demand regions. The 4-MT product pipeline laid by the BPCL from Mumbai to Manmad involves an investment of 4.5 billion rupees.

The Petronet India has also reworked the mega pipeline proposal of the RPL (Reliance Petroleum Limited) and has clubbed it with two other projects – one submitted by the Essar Oil and the other planned by Petronet linking Koyali to Ratlam. The Central India Pipeline, as it will now be called, will begin from Jamnagar and reach Koyali, where a new products storage terminal of the IOC's Gujarat refinery is being planned. From Koyali, the pipeline will extend to Ratlam, where it will bifurcate into two networks.

The other major product pipeline that is under implementation is the 223-km Vishakhaptnam–Vijayawada multi-product pipeline with a capacity of 4 MTPA. This pipeline is being extended to Secundarabad increasing the total length to 588 km.

The 500-km long Chennai–Trichy–Madurai pipeline, with a capacity of 1.4 MTPA, is also due to be completed by 2001. Some of the other pipelines that are being planned include the 350-km Bina–Jhansi–Kanpur pipeline with a capacity of 2.4 MTPA, the 550-km Paradip–Rourkela–Ranchi–Allahabad pipelines with a capacity 2.6 MTPA, and the 400-km Bhatinda–Jalandhar–Jammu pipeline with a capacity of 1 MTPA.

The cost of expanding existing pipelines and implementing new proposals is estimated at 50 billion rupees. In order to generate this large capital investment, an arrangement is required whereby each marketing and refining company has equitable use of the product pipeline capacity. This will include joint venture companies and private sector companies, which operate refineries or participate in the marketing of petroleum products, particularly after the dismantling of the APM (administered pricing mechanism). For this purpose, the government has approved the formation of a holding company (with participation from the public and the private sectors) and subsidiary joint venture companies for the implementation of petroleum product pipeline projects.

Besides having to generate this large capital investment, an arrangement has to be made by the oil industry to ensure equitable use of the available pipeline infrastructure by the marketing and refining companies. The government has recently approved the formulation of a joint venture company called 'Petronet' for putting up new pipelines at an initial cost of 10 billion rupees, with the ultimate objective of forming a pipeline grid. The holding company will consist of four public sector marketing companies, namely, the IOC, the BPCL, the HPCL, and the IBP, of which they will hold equity to the extent of 50%. This move is aimed at attracting private sector investment in pipeline projects, and appears to be a preparatory measure for the complete decontrol of the oil industry.

To ensure the success of the venture, the Working Group on the Petroleum Sector for the Ninth Plan period has recommended that the following policy be re-examined (Planning Commission 1997).

1. The tariff to be charged by the pipeline company should be regulated to ensure adequate return on investments. It has been suggested that the tariffs are linked to the rail freight in order to provide for competition between the two modes.
2. Duty exemption for all materials required for the pipelines may be considered.

Some of the pipelines for which the Feasibility Report has been formulated by the Petronet are as follows.

- Kochi–Coimbatore–Erode–Karur
- Vadinar–Sikka–Kandla
- Mangalore–Hassan–Bangalore
- Bina–Jhansi–Kanpur
- Chennai–Trichy–Madurai

Port infrastructure

At present, about 50% of the crude oil and 20% of the petroleum product requirements are imported, and that crude oil imports are likely to increase in the future. Therefore, it is of utmost importance that the current constraints on port facilities are overcome.

Oil is handled at 13 port facilities in the country. Crude is handled at the ports of Kandla, Mumbai, Kochi, Chennai, Vizag, and Haldia, while petroleum products are handled at the ports of Mangalore, Kandla, Okha, Goa, Tuticorin, Paradip, and Port Blair. In addition, a few products are handled at the ports of Mumbai, Kochi, Chennai, Vizag, and Haldia. In the future, there is a likelihood of concentration of traffic in the Gulf of Kachch due to large volumes of crude import for the Bina, Panipat, Reliance, Essar, and Allahabad refineries.

The past decade saw very little improvements in the port facilities. The government should allow oil companies to undertake projects for augmenting these facilities. Though these facilities are owned by the port authorities, the expenditure to be incurred by the oil industry in this respect is estimated at about 6 billion rupees during the Ninth Five-Year Plan (TERI 1999).

Pricing

The APM constituted a cost-plus pricing system for the producers and a cross-subsidization scheme for the end-users. The Oil Pool Account, an extra budgetary account, reconciled the interests of the consumers and the producers.

The government had appointed a Strategic Planning Group on Restructuring of the Oil Industry 'R Group', comprising eminent experts from the public and private sectors, to make recommendations for meeting the policy objectives of the oil industry. With the help of the Expert Technical Group, the government worked out the details of dismantling the APM[2] and the duty structure for the transition period 1998–2002. The dismantling of APM came into force on 1 April 1998.

According to a study by the NCAER (National Council of Applied Economic Research), the dismantling of APM would result in an overall WPI (wholesale price index) inflation of 1.57% in five years on a cumulative basis.

Some of the impacts of dismantling of the APM are summarized below (MoPNG 1999).

- The cost-plus formula for public sector oil producers has been withdrawn from 1 April 1998. They are now paid a percentage of the weighted average FOB (free on board) price of actual imports of crude oil for indigenous production. However, a floor price of 1991 rupees a tonne has been fixed.
- In the transition phase, the producers of crude oil shall retain a pre-announced increasing share of FOB cost of crude oil while the refineries will have to pay the import parity price for crude. The difference will accrue to the Oil Pool Account to discharge the oil bonds. Indigenous oil producers will pay oil cess of 900 rupees a tonne and royalty out of their own proceeds as in the past.
- The cost-plus formula for shipping of crude has been done away with and market-determined prices are to be paid.
- With effect from 1 April 1998, the refinery gate prices of controlled products, namely, MS, HSD, SKO (superior kerosene oil), LPG, and ATF (aviation turbine fuel), are being fixed on the principle of import parity. However, existing refineries will contribute towards servicing of oil bonds through adjustment during the transition period. Other products of the refineries like naphtha, FO (fuel oil), LSHS (low sulphur heavy stock), wax, and bitumen can be sold at market prices.
- The ex-storage point prices of MS, HSD, kerosene (PDS [public distribution system]), LPG (domestic), ATF, and NGL (natural gas liquids) continue to be determined by the government.
- Private and joint sector refineries have been permitted to import crude oil freely for actual use effective from 13 July 1998.
- Customs duty on crude oil has been reduced from 27% to 22% effective from 2 June 1998.
- With effect from 13 July 1998, FO has been decanalized under the provisions of the Export–Import Policy. Naphtha exports have been decanalized with effect from 8 June 1998.
- The refining sector has been delicensed with effect from 8 June 1998.
- Freight under recoveries on HSD (difference between actual railway freight and notional railway freight) to the extent of 20% has been passed on in the selling prices effective from 9 January 1999.
- The ex-storage point price of LPG (domestic) has been revised with effect from 1 February 1999 and thereafter on 27 February 1999.

The process of liberalization and deregulation is expected to continue during the transition period.[3] Phased reductions in subsidies on kerosene (PDS) and on LPG (domestic) are proposed. The incidence will be transferred to the budget by the end of the transition period.

Trend in oil prices

Driven by oil output cuts by OPEC (Organization of the Petroleum Exporting Countries), international crude prices have risen from 10 dollars a barrel to over 21 dollars a barrel in the period March–August 1999 (Table 20). Dubai crude, the most commonly used crude oil in India, shot up from 10.64 dollars a barrel on 3 March to 14.23 dollars a barrel on 14 April, an increase of 35%. Prices hit 25-year lows below 10 dollars a barrel in 1998. Last year's low crude prices gave India a welcome relief, as oil imports account for around one-fifth of total imports, but the trade deficit still widened to 8.25 billion dollars in 1998/99 from 6.37 billion dollars in the previous year.

A strong rise in international crude oil prices in the recent months could result in an increase in the country's oil import bill by about 2 billion dollars in 1999/2000 (Table VI). The import bill is expected to be at least 30% higher than last year (7.5 billion dollars) and will certainly surpass the 1996/97 record, the highest bill for oil so far.

An increase in the country's oil refining capacity could, however, ease some of the pressure on the import bill as a higher outlay on crude oil would be offset by lower imports of more expensive petroleum

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[2] For the phased programme of reforms for the transition period 1998–2002 as given in the Gazette Notification dated 24 November 1997, see *TEDDY 1998/99*.

[3] For illustration of the current price build-up and the price build-up during the dismantling of the APM for petroleum products, see *TEDDY 1998/99*.

Table VI Oil import bill

	Quantity (million tonnes)		
Year	*Crude oil*	*Petroleum products*	*Oil bill (billion dollar)*
1993/94	30.82	11.82	5.47
1994/95	27.35	13.37	5.48
1995/96	27.23	19.67	6.94
1996/97	33.91	19 47	9.32
1997/98	34.49	18.61	7.39
1998/99	38.00*	19.00*	7.50*
1999/2000	60.00**	9.00**	9.8-10**

* approximately; ** projections

Source Indian Express Newspapers (Bombay Ltd) (18 August 1999)

products (Table VI). Furthermore, the Ministry of Finance is expected to earn about 30 million rupees more than budgeted from customs duty on oil imports if international oil prices continue to rule at the present level of 16–17 dollars a barrel. Revenue on oil import constitutes about 35% of the total customs collection (Table 21). However, the bonanza could be coupled with a reduced inflow into the Oil Pool Account resulting in a deficit, if the government does not initiate timely corrective steps. In this respect, the price of diesel, which is the only controlled product on import parity, is likely to be revised soon in tandem with the changes in the international prices.

The ONGC and the OIL, on the other hand, are poised for a windfall, in the form of at least 4 dollars per barrel gain in crude oil prices beginning June 1999. The state-owned oil exploration and production companies now get a floor price of 1991 rupees a tonne for their oil output, equivalent to roughly 8 dollars a barrel. On 1 April 1999, the ONGC and OIL became entitled to 77.5% of the prevailing international crude price, which was roughly 12.90 dollars a barrel (at a prevailing price of 16.65 dollars a barrel). The floor price was based on the last administered price for crude and fixed at a time when crude prices averaged at 18 dollars per barrel in the key oil markets around the world. The OCC (Oil Coordination Committee), which now charges international crude prices from the refineries but pays the ONGC and OIL a fraction of it, is expected to take the continued crude price spurt since March into cognizance.

Diesel prices in the world oil market have spurted by more than 12%, from 10 dollars per tonne to 12 dollars per tonne. International oil price trends have already had a backlash on the prices of naphtha, LSHS, and FO. Oil companies have effected a steep hike in the prices of three key petroleum products – naphtha, LSHS and FO. The price of LPG for the bulk industry has gone up from 11 000 rupees per tonne to 14 000 rupees per tonne. While the increase has been 7% for naphtha, it is nearly 10% for LSHS and FO. The price of naphtha at all port locations is now 9710 rupees per tonne and will be dearer in inland locations. LSHS will cost 7070 rupees per tonne at port locations. The hike has been pronounced in the case of FO which is now priced at 6600 rupees per kilolitre at all port locations. The increase of 34–39 paise in diesel prices on 19 April only reflected the world price trend evident in February, when the upward spiral in oil prices had only just gained momentum. The OCC, responsible for fixing HSD prices, takes a monthly average of the global trend for the preceding month.

The government, however, has decided against increasing domestic prices of controlled petroleum products or pruning customs duties to reduce the impact of the rising international crude oil prices. Instead, it has decided to absorb the entire impact on the Oil Pool Account for the moment.

Regulatory structure

The terms for offering exploration blocks have now been further liberalized, under the provisions of the NELP, 1999. Apart from better terms offered to the bidders, the outstanding feature of the policy is that it offers a level playing field to the NOCs and private operators. However, despite the attractive terms, the prospects of the blocks under offer do not seem very high and the speed at which the bids will be processed will depend upon the assistance extended by the DGH (Directorate General of Hydrocarbons) and the MoPNG (Ministry of Petroleum and Natural Gas).

The legal framework for regulation of exploration and production of oil and gas is provided by the Oilfields Development and Regulation Act in 1948 and the Petroleum and Natural Gas Rules. The Act has recently been amended to provide for the introduction of the NELP.

The DGH was set up in 1993 with the objective of ensuring correct reservoir management practices, reviewing and monitoring exploratory programmes and development plans for NOCs and private companies, and monitoring of production and optimum exploitation of gas fields. It is obvious that these functions cannot be effectively executed unless the DGH derives its authority from the law. It is, therefore, reported that the government is considering the conversion of the DGH into a statutory authority. The DGH needs to combine regulation with promotion of private sector investments in exploration and production so as to provide a single point reference to the private investor.

The downstream sector, comprising the marketing and refining sectors, is regulated mainly by the Indian Petroleum Act and a number of control orders passed by the government under the Essential Commodities Act. The OCC, which is under the administrative control of the MoPNG, currently performs the function of a planner, coordinator, advisor, and regulator in the downstream sector. During the dismantling of the APM and after, there will be a need for a statutory regulator to undertake these functions for both the public and private sector oil companies till such time as the market becomes fully competitive. The government had assigned TERI the task of drafting a legal framework for the regulation of the downstream sector. The draft is currently under review by the MoPNG.

The government has opted for a four-year transition period for a fully deregulated and competitive oil industry. While it has thrown open the refining sector for private sector participation, the marketing sector is still being controlled substantially.

Private sector participation in the upstream and downstream sectors is expected to achieve the following objectives.

- Bring in additional investments
- Accelerate the development of infrastructure such as refineries
- Give the customer a choice of quality products with improved services
- Provide internationally competitive marketing and distribution management systems thereby improving performance and efficiency

Only those who have invested over 20 billion rupees in refineries or are producing more than 3 MT of crude oil are eligible to have marketing outlets for MS and HSD. A greater deregulation in the marketing sector has been suggested for the operation of a fully competitive market. In addition, a simultaneous opening up of the two sectors may stimulate investments in the refining sector. The reform structure also needs to incorporate the well-being of the economically backward sections of the society or those living in far-flung areas, who, if deprived of the subsidy on petroleum products, may have to be provided with alternatives.

A total decontrol of the downstream sector would imply (1) free sourcing of crude, (2) independent determination of the crude slate and product pattern, (3) removal of marketing and distribution controls, (4) dismantling of the sales plan entitlement, and (5) decontrol of the refining and marketing margins and reseller commission (Srivasatava, Narang, and Sen 1999). In such a scenario, the role of the regulator would be limited only to (1) monitoring the movement of prices and preventing the formation of cartels; (2) facilitating the supply of petroleum products to all areas of the country; (3) ensuring compliance with strategic stockpiling obligations, safety, health, and environmental concerns; (4) providing a quasi-judicial dispute settlement mechanism; (5) facilitating the operationalization of government policy; (6) intervening in times of national and international emergencies; and (7) collecting data on the oil industry.

Apart from the above, regulation would be automatically driven by the forces of competition. However, in light of the infrastructural constraints in the import, transportation, refining, and marketing of products, the regulator would need to manage the transition to a fully deregulated industry. In this respect, the regulator would be involved with the following activities during the transition period.

- Licensing of refineries
- Sourcing of crude imports
- Sourcing of products
- Strategic petroleum reserves
- Refinery production pattern and ex-refinery pricing
- Inland movement of products
- Marketing set-up
- Safety concerns

Oil security concerns

Being a developing economy, our policy makers have been engineering strategies to push her on a path for rapid economic growth to reach a developed country status. Since uninterrupted energy supplies constitute the cornerstone of any rapid industrialization regime, energy security concerns are being revisited now. In fact, energy security concerns assume an even greater significance on account of the increasing demand–supply mismatch, which points towards a growing dependence on imports of energy. Estimates on projected crude imports indicate an import dependence of 75% by 2010. In addition, while there would be a surplus refining capacity in 2005, based on current estimates of planned capacity additions, product imports aggregate to about 27 MT by 2010. The volatility associated with product imports augments the risks in terms of import costs for the economy.

In the long term, India would face a higher reliance on oil imports from the Middle East and would have to face the uncertainties associated with Middle East oil exports. In this respect, some of the prime energy security concerns emerge from the fact that 65% of the world's proven oil reserves are in the Middle East. The low oil prices since the Gulf War may lead to a decline in the economic growth of these countries, and consequent production levels, unless private investments are stepped up. Furthermore, the US sanctions on Iran and Iraq will lead to locking up of reserves in these countries, and in the context of imports from Central Asia these sanctions assume greater significance due to the trade routes through Iran. The power vacuum in the region since the end of the Cold War between the US and Former Soviet Union has also led to doubts regarding political stability in the region.

Security of oil in transit also remains a key issue and calls for a higher degree of policing of the strategic sea lanes of communication and the potential choke points through cooperation of the naval forces of the region.

Energy security concerns have been further fuelled by the paradigm shift to deregulation and liberalization in the Indian economy. In the past, the oil industry has been regulated by the government and in times of crisis the government has come forward to intervene and devise strategies to combat the situation. This response has, however, been more reactive in nature rather than a proactive predetermined policy that ensures supply availability in the event of a crisis. With the move to deregulate the industry, where supplies and allocations would be decided by the market forces, the efficacy of these mechanisms is unknown. In addition, the low international price of oil does not provide the necessary impetus for energy-efficiency initiatives, thereby leading to energy security concerns. While a number of developed economies have resorted to strategic oil reserves to counter short-term disruptions in supplies, India as yet lacks any such reserves. While strategic reserves of 45 days have been accepted by the government, the only stocks currently held are the operational stocks of the oil companies. In addition to parameters such as the composition of stocks, storage options, the organizational structure, and the financial aspect need to be carefully examined. It is estimated that crude oil strategic stocks for 45 days will cost about 2 billion dollars in 2005/06 with an annual cost of 170 million dollars (TERI 1999).

In light of the concerns mentioned above, some of the response strategies that need to be developed proactively to safeguard against an oil supply disruption include (1) diversification of sources of supply, (2) demand restraint measures, (3) fuel-switching options, (4) strategic stockpiles, and (5) initiatives for regional cooperation.

Recognizing the need for diversification of sources of supply and the limited domestic reserve accretion, the OVL (ONGC Videsh Limited), a wholly owned subsidiary of the Oil and Natural Gas Corporation, is involved exclusively in foreign ventures, including acquisition of acreage and exploration and production operations. In addition to the exploratory projects in the Sakhalin area of Russia and the Caspian Basin, it has already entered into joint ventures with the IOC and GAIL (Gas Authority of India Limited) for exploration in the CIS (Commonwealth of Independent States) and with the Reliance India Limited for a discovered oil field (Tuba) in Iraq. The OVL is negotiating with various companies and is willing to offload certain amount of its equity to a strategic partner with enough financial muscle for jointly undertaking exploration and production projects abroad. The OVL is in the process of finalizing a strategic partner for going ahead with a recently bagged upstream project in Vietnam involving an investment of about 10 billion rupees.

Although there is considerable scope for regional cooperation for ensuring energy security, the natural gas pipeline from Bangladesh, for instance, has not fructified on account of political uncertainties. These issues need to be, therefore, resolved in a bilateral/multilateral manner so as to benefit from the resource endowments in the region.

Natural gas

Demand and supply

The advancements in gas utilization technologies as well as environmental concerns are responsible for the growth in gas demand. The capacity-addition programme in the power sector, more stringent environmental stipulations, and advancements in gas turbine technologies have resulted in gas emerging as a preferred fuel for power generation. Natural gas currently accounts for about eight per cent of the energy consumption in the country. The total gas consumption during 1997/98 was 19 BCM (Table 18) with the sectoral distribution as illustrated in Figure 4.

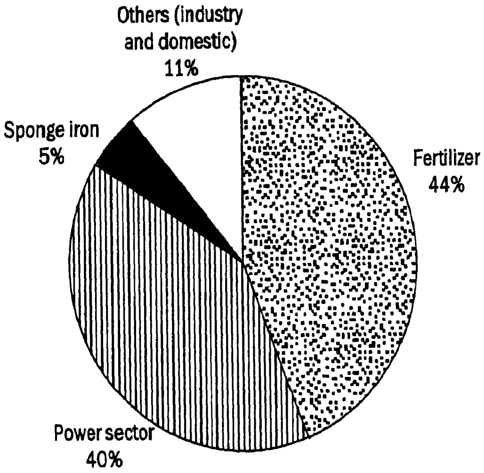

Figure 4 End-use pattern of natural gas by sector
Source Planning Commission (1997a)

The aggregate natural gas production during 1997/98 was 26 billion cubic metres and is likely to peak in the next two to three years. However, a wide gap is expected to prevail between the domestic supply of gas and its potential demand unless major gas discoveries materialize following future exploration by PSUs and private companies. In the Indian context, gas/LNG (liquefied natural gas) imports can ease the shortage of primary energy supply provided it can be sourced at competitive prices with respect to domestic and imported alternative fuels.

India is considering pipeline gas as well as LNG imports from countries in the west and south-east Asia to meet the gas demand of markets predominantly in the northern, western, and southern regions. Importing LNG is an attractive option as it allows the market to build up in a phased manner and hence provide better flexibility from the marketing and operational aspects.

High priority has been assigned to LNG imports at Ennore (Tamil Nadu) and Dahej (Gujarat) to meet the gas requirements of the southern and western regions, respectively. The LNG imports are also planned at Hazira and Kochi. The Petronet LNG has recently signed a 25-year sale-purchase agreement with the Qatar-based Ras Laffan Liquefied Natural Gas Company for supply of 5 MTPA and 2.5 MTPA of LNG for its terminals being set up at Dahej in Gujarat and Kochi in Kerala, respectively.

In India, gas/LNG imports are being linked with power projects and would replace domestic coal. Thus the economics of gas imports would depend upon factors such as the transportation costs and the ability of the power sector to pay for gas as a substitute for coal or another alternative fuel (Planning Commission 1997a).

In the longer term, various supply options such as coal-bed methane, exploitation of gas hydrates, and in situ coal gasification are being considered. The government has issued policy guidelines for the recovery of coal-bed methane offering fiscal and financial incentives to Indian and foreign investors.

Transport infrastructure

The existing gas infrastructure supports production and transportation of about 90 million cubic metres per day of gas and transmission and distribution of about 65–70 MCM (million cubic metres) a day. The western offshore region is the major source of gas, accounting for more than 70% of the total gas production. Adequate offshore facilities exist for the compression and evacuation of gas to shore-based facilities at Uran in Maharashtra and Hazira in Gujarat. The shore-based facilities in Uran can receive gas from two offshore trunk gas pipelines, namely, Bombay High to Uran and Heera Field to Uran. Similarly, the shore-based facilities at Hazira receive gas from two offshore gas trunk pipelines from the South Bassein field.

The Bombay High–Uran pipeline has a diameter of 65 cm and a capacity of about 13 MCM a day. The two gas pipelines from South Bassein to Hazira are 90 cm and 105 cm in diameter with capacities of 22 and 30 MCM a day, respectively. The terminal at Uran can handle 16 MCM of gas a day. The terminal at Hazira is being expanded to handle 41 MCM of gas a day. The expected gas supply from the western offshore region in 2000 is estimated at about 68 MCM a day. The Hazira terminal has the gas sweetening facilities for treatment of sour gas from South Bassein and other offshore fields.

As far as the gas transmission and distribution network is concerned, a system of about 3800-km long pipeline trunk as well as spur (consumer) lines is presently in position. The largest pipeline system is the HBJ (Hazira–Bijapur–Jagdishpur) trunk pipeline system, which is more than 2000 km in length (Map 2, Annexure II). The capacity of the HBJ system has been expanded from 18.3 MCM a day to 33.4 MCM a day in July 1998 at a cost of 23.76 billion rupees. As part of the expansion plan, a trunk section (90 cm in diameter) has been added between Bijapur and Dadri. In addition, there are regional gas grids of varying sizes in Gujarat (Cambay Basin), Andhra Pradesh (Krishna–Godavari Basin), Assam (Assam–Arakan Basin), Maharashtra (Ex-Uran terminal), Rajasthan (Jaisalmer Basin), Tamil Nadu (Cauvery Basin), and Tripura (Arakan Basin).

The present grid spread is based on the gas availability from the regions as well as the projections for future gas production. However, no major pipelines have been planned for the next two to three years even though gas production from domestic reserves is expected to peak by 2002. Major pipeline activity would be triggered when the pipeline gas import projects materialize. Utilization of imported gas would require major trunk gas pipeline systems for transportation of gas to various regional markets. The imports of LNG would also lead to the requirement of new pipelines. GAIL is already laying a pipeline from Kandla to the northern region of the country.

Pricing

For the future demand–supply perspective, it would be important to take the domestic gas pricing closer to the inter-fuel market-determined pricing regime. The deregulation of natural gas pricing has been undertaken concurrently with the dismantling of the APM for crude oil and petroleum products so as to establish a rational market-related pricing framework for the end-users.

With effect from 1 October 1997 up to 3 March 2000, the consumer price of gas at landfall points would be linked to the price of a basket of LSHS/FO as shown in Table VII (MoPNG 18 September 1997). It is likely that the prices would be raised to 100% parity with FO by 2001/02. The price of gas produced from medium-sized fields developed through joint ventures is already at 100% fuel parity.

The main features of the new gas pricing policy issued by the MoPNG are given in Box 2.

Table VII Natural gas prices

Year	*As percentage of general price*	*Low sulphur heavy stock/fuel oil prices (Concessional price for the north-eastern region)*
1997/98	55%	30%
1998/99	65%	40%
1999/2000	75%	45%

Source MoPNG (18 September 1997)

The government reduced the price of natural gas by 4.94%–8.4% for the first quarter of 1998/99, following the fall in international prices of low and high sulphur FO. The producer price was reduced by about 8.48% while the general consumer price was reduced by 5.8% in states other than those in the north-east. The prices for the first quarter of

Box 2 Highlights of the natural gas pricing policy

- The price would be determined and notified for every quarter depending on the average prices of the basket of fuel oil based on the figures obtained from Platts Oilgram for the previous quarter. The general and concessional price will be fixed as given in Table VII.
- The consumer price of gas as above would be linked to a calorific value of 10 000 kilocalories per cubic metre.
- The consumer price of gas will be reviewed at the end of the first three years (1997-2000) with a view to achieve 100% fuel oil parity prices over the fourth and fifth years.
- Over the period 1 October 1997 to 31 March 2000, the transportation charge payable to GAIL (Gas Authority of India Limited) along the Hazira-Bijapur-Jagdishpur pipeline would be 1150 rupees per million cubic metre. This will increase by 1% for every 10% increase in the consumer price index. This increase will be paid to GAIL from the Gas Pool Account.
- In addition to the price as described above, the transportation charges, royalty, taxes, duties, and other statutory levies on production, transportation, and sale of natural gas will be payable by the consumers.
- Of the consumer prices collected by GAIL, the amount required to pay for the higher cost of gas purchased from the joint venture companies will be retained.

Source MoPNG (18 September 1997)

1998/99 and 1999/2000 have been illustrated in Figures 5(a) and 5(b). Quarterly natural gas prices are provided in Table 24.

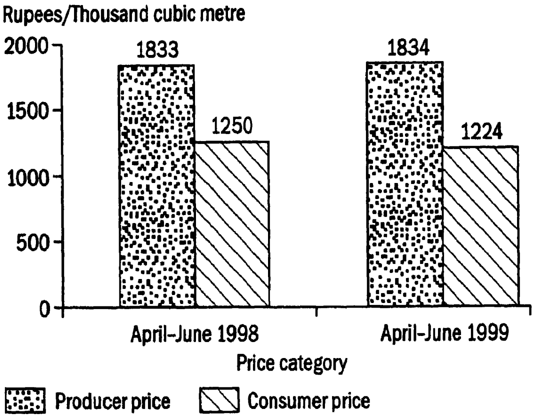

Figure 5(a) Natural gas prices in the north-eastern states
Source Data obtained from the MoPNG

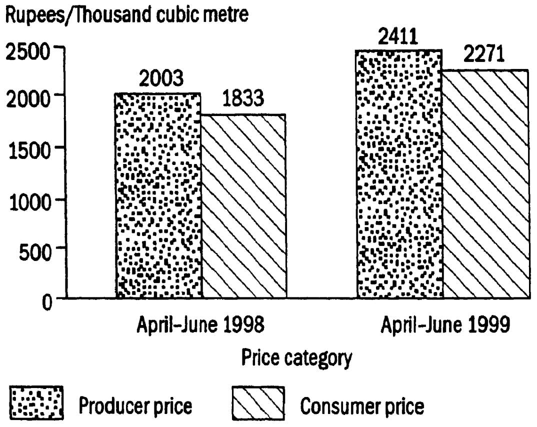

Figure 5(b) Natural gas prices in other states
Source Data obtained from the MoPNG

Regulatory structure

Although commercial utilization of gas started in the 1960s, it accelerated only after the development of the western offshore fields in the late seventies. The Seventh and Eighth Plan periods experienced a rapid increase in gas utilization, with the current level at about 24 billion cubic metres annually. In 1986, the HBJ pipeline was laid to bring the western offshore gas to fertilizer plants in western and northern states. Since 1987, the government has been fixing the price of gas, and it has also been deciding the allocation of gas to competing consumers. However, having decided to deregulate the sector, the government will need to bring in suitable legislation to appoint an independent regulator for the gas industry.

The transportation of gas through pipelines involves significant economies of scale and very little inter-modal competition, thereby calling for a set of regulations not required for petroleum products. The aspects that need to be considered for regulation are (1) common carriage versus contract carriage, (2) authorization for gas transportation and distribution, (3) unbundling of trading and transmission, (4) cross-ownership between distribution and transmission, (5) fixing of transportation and distribution charges, (6) regulation of the LNG sector, (7) open access for spare pipeline capacity, (8) pricing and allocation of natural gas, and (9) distribution networks.

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ऑयल इंडिया लिमिटेड
(भारत सरकार का उद्यम)

Oil India Limited
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Table 1

Proven and balance recoverable reserves of crude oil (million tonnes) and natural gas (billion cubic metre) by state: 1975 to 1997

Crude oil and natural gas	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Crude oil											
Onshore											
Gujarat	45.7	52.7	86.6	161.7	158.3	156.6	155.1	153.4	153.2	—	—
Assam	84.4	82.7 *	101.8 *	145.0	156.2 *	160.8 *	158.2 *	156.1 *	147.9 *	—	—
Total	130.1	135.4	188.4	306.7	314.5	317.4	313.3	309.5	301.1	304.0	320.0
Offshore											
Bombay High	13.8	231.0	311.1	432.1	491.7	483.7 †	465.8 †	455.2 †	431.1 †	423.0	426.0
Total (crude oil)	**143.9**	**366.4**	**499.5**	**738.8**	**806.2**	**801.1**	**779.1**	**764.7**	**732.2**	**727.0**	**726.0**
Natural gas											
Onshore											
Gujarat	15.7	16.4	21.9	92.6	93.4	94.0	92.9	92.1	89.9	—	—
Assam	65.2	63.5 ‡	87.7 ‡	135.5 ‡	151.7 ‡	160.5 ‡	156.1 ‡	156.2 ‡	159.2 ‡	—	—
Rajasthan	0.4	0.4	0.5	1.0	1.2	1.3	3.8	3.8	4.1	—	—
Total	81.3	80.3	110.1	229.1	246.3	255.7	252.8	252.1	253.2	263.0	274.0
Offshore											
Bombay High	6.3	271.0	368.6	457.4	483.5	479.8 §	465.1 §	454.6 §	406.5 §	377.0	418.0
Total (natural gas)	**87.6**	**351.3**	**478.7**	**686.5**	**729.8**	**735.6**	**717.9**	**706.7**	**659.7**	**640.0**	**692.0**

* includes crude oil onshore reserves in Nagaland and onshore reserves in Andhra Pradesh and Tamil Nadu

† includes crude oil offshore reserves in Andhra Pradesh and Tamil Nadu

‡ includes natural gas onshore reserves in Tripura, Nagaland, Tamil Nadu, Arunachal Pradesh, and Andhra Pradesh

§ includes natural gas offshore reserves in Andhra Pradesh, Gujarat, Tamil Nadu, and Andaman and Nicobar Islands

Sources

1. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.
2. MoPNG. 1998. Basic Statistics on Indian Petroleum & Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exploration, reserves, and production)]

Table 2

Exploratory and developmental drilling by the Oil and Natural Gas Corporation Ltd and the Oil India Ltd: 1975/76 to 1997/98

Drilling (wells and metreage)	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* †
Exploratory											
Wells											
Onshore	50 *	45 *	94 £	176	176	172	147	166	177	171	114
Offshore	10	16 *	35 ‡	73	61	69	33	48	27	28	20
Total	**60** *	**61** ‡	**129** #	**249**	**237**	**241**	**180**	**214**	**204**	**199**	**134**
Metreage (km)											
Onshore	120	96	237	434	454	413	374	445	427	407	297
Offshore	19	40	100	184	167	176	96	116	77	80	50
Total	**139**	**136**	**337**	**618**	**621**	**589**	**470**	**561**	**504**	**487**	**347**
Developmental											
Wells											
Onshore	69 *	40 ‡	135 **	220	193	196	205	191	171	156	135
Offshore	5	18	44	66	22	31	129	41	52	18	38
Total	**74** *	**58** ‡	**179** **	**286**	**215**	**227**	**334**	**232**	**223**	**174**	**173**
Metreage (km)											
Onshore	145	71	283	455	401	441	509	475	384	355	326
Offshore	9	42	89	92	41	75	264	88	86	48	82
Total	**154**	**113**	**372**	**547**	**442**	**516**	**773**	**563**	**470**	**403**	**408**

†	provisional
*	includes one partly-drilled well
‡	includes two partly-drilled wells
£	includes four partly-drilled wells
#	includes six partly-drilled wells
**	includes seven partly-drilled wells

Sources

1. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues) New Delhi· Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 3

Production (thousand tonnes) of crude oil and natural gas (million cubic metres): 1975/76 to April–December 1998

State	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998*
† **Crude oil production**												
Onshore												
Gujarat	4148	3808	4319	6398	6035	5807	5076	6279	6362	6158	5951	4402
Assam/Nagaland	4300	1712	4966	5076	4899	4986	5090	5043	5044	4796	5114	4005
Arunachal Pradesh	—	2	60	43	42	59	49	35	28	36	27	27
Tamil Nadu/ Andhra Pradesh	—	—	—	313	318	352	536	656	418	382	390	336
Total	**8448**	**5522**	**9345**	**11830**	**11383**	**11204**	**11651**	**12013**	**11852**	**11372**	**11482**	**8770**
Of which												
AOC (Assam Oil Company)	66	48	—	—	—	—	—	—	—	—	—	—
OIL (Oil India Limited)	3103	1243	2654	2649	2529	2523	2811	2883	2882	2870	3094	2475
ONGC (Oil and Natural Gas Corporation Ltd)	5279	4231	6691	9181	8854	8681	8840	9130	8970	8502	8388	6295
Offshore												
ONGC	—	4985	10712	21191	18963	15746	15375	20226	22665	20183	19863	13799
Private/Joint venture company	—	—	—	—	—	—	—	—	650	1346	2514	1962
Grand total	**8448**	**10507**	**30168**	**33021**	**30346**	**26950**	**27026**	**32239**	**35167**	**32901**	**33859**	**24531**
Natural gas production												
Onshore												
Gujarat	773	842	919	1696	1698	1946	2166	2462	2878	2932	3115	2369
Assam/Nagaland	1595	843	2029	2011	31	52	47	1909	1880	1941	2018	1541
Arunachal Pradesh	—	—	6	29	271 §	676 §	788 §	37	32	23	24	17
Tripura	—	—	—	70	—	—	—	97	131	154	196	232
Tamil Nadu	—	—	—	64	—	—	—	98	117	92	95	76
Andhra Pradesh	—	—	—	46	—	—	—	640	679	799	1022	899
Rajasthan	—	—	—	—	—	—	—	—	12	10	148	121
Total	**2368**	**1685**	**2954**	**3916**	**4251**	**4708**	**4979**	**5243**	**5729**	**5951**	**6618**	**5255**
Of which												
AOC	—	38	—	—	—	—	—	—	—	—	—	—
OIL	—	710	1553 ‡	1518	—	—	—	1435	1433	1467	1670	1269
ONGC	—	937	1401	2398	—	—	—	3808	4296	4484	4948	3986
Offshore	—											
ONGC	—	673	5180	14082	14394	13352	13356	14138	16579	16794	18102	13404
Private/Joint venture company	—	—	—	—	—	—	—	—	331	510	1681	2075
Grand total	**2368**	**2358**	**8134**	**17998**	**18645**	**18060**	**18335**	**19381**	**22639**	**23255**	**26401**	**20734**

† includes condensates
‡ the AOC was merged with the OIL w.e.f 14 October 1981
§ includes Tripura, Tamil Nadu, and Andhra Pradesh

Sources
1. MoPNG. 1998. Basic Statistics on Indian Petroleum & Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas
2. MoPNG. 1999. Annual Report 1998/99. New Delhi: Ministry of Petroleum and Natural Gas

Table 4

Natural gas production and supply (million cubic metres per day) of companies: 1992/93 to 1997/98

Company	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Oil and Natural Gas Corporation Ltd						
Production	45.17	46.07	49.17	57.04	58.30	63.15
Flared	3.89	4.02	4.62	3.07	3.60	3.79
Utilization	41.28	42.05	44.55	53.97	54.70	59.36
Utilization (%)	91.40	91.30	90.60	94.60	93.80	94.00
Internal use	5.56	5.41	6.30	7.39	7.52	8.35
Out of which LPG (liquefied petroleum gas)/C2–C3 shrinkage	1.64	1.71	2.07	2.30	2.34	2.42
Supply	35.72	36.64	38.25	46.58	47.18	51.01
Oil India Limited						
Production	4.28	4.17	3.93	3.92	4.15	4.58
Flared	1.19	1.27	0.92	0.73	0.47	0.47
Utilization	3.09	2.90	3.01	3.19	3.68	4.11
Utilization (%)	72.20	69.50	76.60	81.40	88.70	89.70
Internal use	1.05	1.15	1.12	1.06	1.05	1.03
Out of which LPG/C2–C3 shrinkage	0.10	0.10	0.10	0.10	0.10	0.10
Supply	2.04	1.75	1.89	2.13	2.63	3.08
Joint venture/Private parties						
Production	0.00	0.00	0.00	0.91	1.40	4.61
Flared	0.00	0.00	0.00	0.87	1.23	0.84
Utilization	0.00	0.00	0.00	0.04	0.07	3.77
Utilization (%)	0.00	0.00	0.00	4.40	12.10	81.80
Internal use	0.00	0.00	0.00	0.02	0.03	0.09
Supply	0.00	0.00	0.00	0.02	0.14	3.68
All companies						
Production	49.45	50.24	53.10	61.87	63.85	72.34
Flared	5.08	5.29	5.54	4.67	5.30	5.10
Utilization	44.37	44.95	47.56	57.20	58.55	67.24
Utilization (%)	89.70	89.50	89.60	92.50	91.70	92.90
Internal use	6.61	6.56	7.42	8.47	8.60	9.47
Out of which LPG/C2–C3 shrinkage	1.74	1.81	2.17	2.40	2.44	2.52
Total supply	37.76	38.39	40.14	48.73	49.95	57.77

Source

OCC. November 1998. Ready Reckoner. New Delhi: Oil Coordination Committee.

Table 5

Reserve replacement ratio and life of reserves for crude oil (million tonnes) and natural gas (billion cubic metres): 1975 to 1996/97

	Crude oil						Natural gas					
Year	Recoverable reserves	Net addition/ depletion	Production	Gross addition to recoverable reserves	Reserves replacement ratio *	Life of reserves (years of current production)	Recoverable reserves	Net addition/ depletion	Production	Gross addition to recoverable reserves	Reserves replacement ratio *	Life of reserves (years of current production)
1975	275	131	8.3	139.3	16.8	33.1	185	97.0	2.3	99.3	43.2	80.4
1980	469	103	9.4	112.4	12.0	49.9	411	59.0	2.1	61.1	29.1	195.7
1981	470	1	14.9	15.9	1.1	31.5	420	9.0	3.5	12.5	3.6	120.0
1982	526	56	19.7	75.7	3.8	26.7	475	55.0	4.7	59.7	12.7	101.1
1983	511	- 15	25.1	10.1	0.4	20.4	478	3.0	5.8	8.8	1.5	82.4
1984	500	- 11	27.9	16.9	0.6	17.9	479	1.0	6.8	7.8	1.2	70.4
1985	558	58	29.9	87.9	2.9	18.7	497	18.0	7.9	25.9	3.3	62.9
1986	581	23	31.2	54.2	1.7	18.6	541	44.0	9.5	53.5	5.6	57.0
1987	638	57	30.1	87.1	2.9	21.2	579	38.0	10.9	48.9	4.5	53.1
1988	726	88	31.6	119.6	3.8	23.0	648	69.0	12.8	81.8	6.4	50.6
1989	739	13	33.7	46.7	1.4	21.9	686	38.0	15.9	53.9	3.4	43.1
1990	806	67	33.3	100.3	3.0	24.2	730	46.0	18.0	64.6	3.5	39.3
1991	801	- 5	31.0	26.0	0.8	25.8	736	6.0	18.7	24.7	1.3	39.4
1992/93	779	- 22	27.0	5.0	6.2	28.9	718	-18.0	18.1	-1.0	—	39.7
1993/94	765	- 14	27.0	13.0	0.5	28.3	707	-11.0	18.3	7.3	0.4	38.6
1994/95	732	- 33	32.2	0.8	0.02	22.7	660	-47.0	19.4	-27.6	-1.4	34.0
1995/96	727	- 5	35.2	30.2	0.86	20.7	640	-20.0	22.3	2.3	0.1	28.7
1996/97	746	19	32.9	51.9	1.58	—	692	52	22.7	0.4	0.2	—

* defined as a ratio of gross addition of reserves to total production during the year

Note

The oil and natural gas reserves data are taken at the end of each calendar/financial year and production during the year for the purpose of calculation

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exploration, reserves, and production)]

Table 6

Petroleum refining capacity (million tonnes) and refinery crude throughput, production, and losses

Refining company	Commissioning year	Capacity at the time of commissioning	Installed capacity (1 April 1998)	Crude throughput (1996/97)	1997/98 Crude throughput	1997/98 Refinery Production †	1997/98 Refinery losses *
Bharat Petroleum Corporation Ltd, Mumbai	1955	2.2	6.00	7.64	7.99	6.45	1.54
Bongaigaon Refinery and Petrochemicals Ltd, Bongaigaon	1979	1.0	2.35	1.54	1.72	—	—
Cochin Refineries Ltd, Kochi	1966	2.5	7.50	7.30	7.73	—	—
HPCL (Hindusthan Petroleum Corporation Ltd), Mumbai	1954	—	5.50	6.54	6.38	5.99	0.37
HPCL Visakhapatnam	1957	—	4.50	4.85	2.47	2.30	0.14
IOC (Indian Oil Corporation Ltd) Barauni	1964	2.0	3.30	1.90	2.18	2.04	0.14
IOC Ltd, Digboi	1901	0 5	0.65	0.48	0.50	0.47	0.03
IOC Ltd, Guwahati	1962	0.8	1.00	0.85	0.86	0.81	0.05
Indian Oil Corporation Ltd, Haldia	1974	2.5	3.75	3.45	4.71	4.42	0.29
IOC Ltd, Gujarat	1965	—	9.50	10.35	10.69	10.05	0.64
Indian Oil Corporation Ltd, Mathura	1982	6.0	7.50	8.11	8.56	8.03	0.53
MRL (Madras Refinery Ltd), Chennai	1969	2.5	6.50	6.62	6.96	6.46	0.50
MRL Narimanam	1993✓	0.5	0.50	0.35	0.56	0.52	0.04
MRPL (Mangalore Refinery and Petrochemicals Ltd), Mangalore	1996	3.0	3.00	2.90	3.87	—	—
Total			**61.55**	**62.87**	**65.18**	**47.53**	**4.30**

* refinery fuel and loss figures are based on the assumption that intermediate stock differential of refineries remains unchanged, an average figure for refinery losses has been used for each company

† the refinery production crude throughput – refinery losses

Note

The individual refinery crude throughput, refinery production, and losses may not add up to total due to rounding off

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG 1997. Basic Statistics on Indian Petroleum & Natural Gas New Delhi Ministry of Petroleum and Natural Gas.

3. MoPNG. 1998 Annual Report 1997/98 New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE + [Section: Oil and gas (refining capacity, throughput, stocks)]

Table 7

Refinery crude throughput and production (thousand tonnes) of petroleum products: 1975/76 to April–December 1998

Parameter	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998*
Crude throughput	22283	25836	42910	51772	51423	53482	54296	56534	58741	62870	65166	50133
Production	20829	24123	39881	48562	48349	50359	51084	52927	55081	59005	61308	47066
Refinery losses	1454	1713	3029	3210	3074	3123	3212	3607	3660	3865	3858	3067
Losses (%)	6.5	6.6	7.1	6.2	6.0	5.8	5.9	6.4	6.2	6.1	5.9	6.1
Refinery capacity utilization (%)	—	—	—	—	99.2	103.1	102.9	105.9	104.2	104.1	105.9	106.7

Sources

1. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues). New Delhi. Economics and Statistics Division, Ministry of Petroleum and Natural Gas.
2. MoPNG. 1997. Basic Statistics on Indian Petroleum & Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas
3 MoPNG. 1999 Annual Report 1998/99 New Delhi· Ministry of Petroleum and Natural Gas

Table 8

Production (thousand tonnes) of petroleum products: 1975/76 to April–December 1998

Petroleum products	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998*
Light distillates												
Liquefied petroleum gas	331	366	867	1221	1250	1249	1314	1432	1539	1598	1666	1247
Motor gasoline	1275	1519	2306	3552	3420	3709	3843	4129	4462	4704	4849	4057
Naphtha	1910	2115	4955	4859	4546	4586	4666	5662	5975	6123	6103	4422
Others	114	101	125	391	457	422	295	402	457	458	414	295
Total	**3630**	**4101**	**8253**	**10023**	**9673**	**9966**	**10118**	**11625**	**12433**	**12883**	**13032**	**10021**
Middle distillates												
Kerosene	2439	2396	4030	5471	5339	5199	5266	5261	5267	6236	6701	4093
Aviation turbine fuel	925	1001	1519	1801	1539	1636	1788	1968	2127	2119	2147	1701
High speed diesel oil	6285	7371	14624	17185	17404	18289	18809	19593	20661	22202	23354	19211
Light diesel oil	946	1108	1177	1509	1482	1453	1474	1364	1351	1286	1246	989
Others	174	239	263	378	607	427	462	509	535	580	485	350
Total	**10769**	**12115**	**21613**	**26344**	**26371**	**27004**	**27799**	**28695**	**29941**	**32423**	**33933**	**26344**
Heavy ends												
Furnace oil	3595	4041	3791	4879	5430	6359	6163	5728	5351	5980	6771	4729
Low sulphur heavy stock	1488	2079	4164	4550	4207	4044	4141	4094	4228	4318	4309	3411
Lube oils	342	426	501	561	390	533	489	504	633	619	593	446
Petroleum coke	160	86	192	229	216	221	233	259	256	246	282	203
Bitumen	697	1082	1107	1603	1710	1862	1874	1845	2032	2283	2158	1699
Others	148	193	260	373	352	370	267	177	207	252	230	213
Total	**6430**	**7907**	**10015**	**12195**	**12305**	**13389**	**13167**	**12607**	**12707**	**13698**	**14343**	**10701**
Grand total	**20829**	**24123**	**39881**	**48562**	**48349**	**50359**	**51084**	**52927**	**55081**	**59005**	**61308**	**47066**

includes hot heavy stock and residual fuel oil

Sources

1. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.
2 MoPNG. 1998. Basic Statistics on Indian Petroleum & Natural Gas New Delhi Ministry of Petroleum and Natural Gas.
3. MoPNG. 1999. Annual Report 1998/99. New Delhi Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE + [Section: Oil and gas (refining capacity, throughput, stocks)]

Table 9

Imports/exports of crude oil and petroleum products: 1975/76 to April–December 1998

Imports/exports	*Unit*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998*
Crude oil													
Imports													
Gross quantity	Thousand tonnes	13624	16248	15144	20699	23994	29247	30822	27349	27342	33906	34494	29506
Gross value	Million rupees	10518	33490	36868	61184	78201	106859	106885	103160	115170	185381	158971	110403
Net quantity	Thousand tonnes	13624	16248	14616	20699	23994	29247	30822	27349	27342	33906	34494	34494
Net value	Million rupees	10518	33490	35519	61184	78201	106859	106885	103160	115170	185381	158971	110403
Exports													
Gross quantity	Thousand tonnes	0	0	528	0	0	0	0	0	0	0	0	0
Gross value	Million rupees	0	0	1352	0	0	0	0	0	0	0	0	0
Petroleum products													
Imports													
Gross quantity	Thousand tonnes	2218	7289	3865	8660	9445	11283	12076	13951	20335	20265	19530	14146
Gross value	Million rupees	2043	19175	12736	46602	52183	63596	70414	75217	125779	156334	124319	74894
Net quantity	Thousand tonnes	2048	7253	1902	6012	6509	7564	8042	10697	16900	17103	16576	12983
Net value	Million rupees	1903	19091	7640	36563	40036	47533	55326	59343	107459	135538	106039	67669
Exports													
Gross quantity	Thousand tonnes	170	36	1963	2648	2936	3719	4034	3254	3435	3162	2954	1163
Gross value	Million rupees	140	84	5096	10039	12147	16063	15088	15874	18319	20796	18280	7224

* provisional and excludes imports made by private companies

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 1997 Basic Statistics on Indian Petroleum & Natural Gas New Delhi: Ministry of Petroleum and Natural Gas

3 MoPNG 1999 Annual Report 1998/99 New Delhi Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exports and imports)]

Table 10

Imports/exports (thousand tonnes) of crude oil and petroleum products 1975/76 to April–December 1998

Item	1975/76	1980/81	1985/86	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998
† **Gross imports**												
Crude oil	13624	16248	15144	20699	23994	29247	30822	27349	27342	33906	34494	29506
Petroleum, oil, and lubricants												
Light distillates												
Naphtha	—	—	—	—	—	—	—	—	—	—	—	—
Liquefied petroleum gas	—	—	—	329	215	328	410	592	678	1035	1087	1039
Others	—	—	38	5	47	8	4	2	439	455	335	290
Sub-total	**‡**	**231 ‡**	**38**	**334**	**262**	**336**	**414**	**594**	**1117**	**1490**	**1422**	**1331**
Middle distillates												
Aviation turbine fuel	—	32	150	27	24	—	—	78	97	150	55	—
Kerosene	726	2065	2568	3340	3367	3463	3946	4240	5001	4279	3812	4421
High speed diesel	609	3287	890	4680	5329	7159	7555	8637	12852	13608	14075	7869
Sub-total	**1335**	**5615 §**	**3608**	**8047**	**8720**	**10622**	**11501**	**12955**	**17950**	**18037**	**17942**	**12290**
Heavy ends												
Furnace oil	784	1336	20	—	—	—	—	267	1209	694	141	514
Lubes	65	175	195	256	412	296	132	87	58	44	25	11
Waxes	—	—	4	23	25	29	29	20	—	—	—	—
Refined petroleum coke	—	—	—	—	26	—	—	—	—	—	—	—
Others	34	127	—	—	—	—	—	28	—	—	—	—
Sub-total	**883**	**1638**	**219**	**279**	**463**	**325**	**161**	**402**	**1268**	**738**	**166**	**525**
Total imports	**2218**	**7289 £**	**3865**	**8660**	**9445**	**11283**	**12076**	**13951**	**20335**	**20265**	**19530**	**14146**
Exports												
Crude oil	—	—	528	—	—	—	—	—	—	—	—	—
Petroleum, oil, and lubricants												
Light distillates	—	—										
Naphtha	—	—	1796	1520	1423	1518	1625	2249	2461	2184	1407	643
LPG	—	—	—	—	—	—	9	12	17	22	21	16
Others	170	—	16	604	694	917	803	609	539	437	641	103
Sub-total	**170**	**—**	**1812**	**2124**	**2117**	**2435**	**2437**	**2870**	**3017**	**2643**	**2102**	**762**
Middle distillates												
High speed diesel/light diesel oil	—	—	66	82	125	146	155	182	209	216	237	192
Others	—	—	64	79	107	129	137	170	187	221	254	194
Sub-total	**—**	**—**	**130**	**161**	**232**	**275**	**292**	**352**	**396**	**437**	**491**	**386**
Heavy ends												
Furnace oil/low sulphur heavy stock	—	—	14	357	583	1003	1288	29	22	82	360	15
Others	—	—	7	6	4	6	17	3	—	—	1	—
Sub-total	**—**	**—**	**21**	**363**	**587**	**1009**	**1305**	**32**	**22**	**82**	**361**	**15**
Total exports	**170**	**36 ‡**	**1963**	**2648**	**2936**	**3719**	**4034**	**3254**	**3435**	**3162**	**2954**	**1163**

† includes national oil company imports but excludes imports made by private companies
‡ break-up not available
§ includes light distillates
£ the sub-totals may not add up the total due to the inclusion of unspecified products

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG 1999 Annual Report 1998/99 New Delhi Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section. Oil and gas (exports and imports)]

Table 11

Movement of petroleum products by railways: 1975/76 to 1996/97

	1975/76	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Tonnes originating (thousand tonnes)	11663	14954	18635	24988	25555	26412	25950	27724	28909	28590
Average lead distance (km)	605	780	588	605	606	603	638	655	667	656
Earnings (paise/tonne-km)	12.2	15.7	42.9	63.6	66.3	73.7	88.9	99.1	103.7	111.2

Source

MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas

Table 12

Petroleum products handled at major ports (million tonnes)

Port	*Port capacities as on 31 March 1998*	*1996/97*	*1997/98*	*Utilization in 1997/98 (%)*
Calcutta	3.1	2.5	3.8	121
Haldia	8.5	8.5	10.6	124
Kandla	23.0	25.1	29.0	126
Kochi	10.5	9.2	9.8	93
Madras	8.5	12.5	11.6	136
Mormugao	1.5	1.2	1.1	75
Mumbai	21.0	18.7	16.7	80
New Mangalore	7.5	4.9	6.5	87
Paradip	0.7	1.7	1.7	249
Tuticorin	1.1	0.4	0.4	36
Visakhapatnam	11.5	13.4	12.1	105
Total	**96.9**	**98.1**	**104.0**	**107**

Source

MoST 1999 Basic Port Statistics 1997/98 New Delhi: Ministry of Surface Transport.

Table 13

Product storage and movement: 1993/94 to 1997/98

Mode of transport	*Unit*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Road	Million tonnes	15.3	17.9	22.2	—	—
	Percentage	25.2	27.3	30.6	—	—
Rail	Million tonnes	26.1	28.0	30.2 †	29.6 †	32.0 †
	Percentage	42.9	42.8	41.7	38.3	39.9
Pipelines	Million tonnes	15.0	15.4	15.9	19.2	20.7
	Percentage	24.7	23.5	21.9	24.9	16.6
Coastal	Million tonnes	4.9	4.6	5.5	—	—
	Percentage	8.1	7.0	7.6	—	—
Marketing infrastructure						
Total no. of terminals and depots		—	333	—	—	—
Total no. of bottling plants						
Existing		—	98	—	—	—
Proposed up to the end of Ninth Plan		—	115	—	—	—
Tankage	Million tonnes	—	13.86	—	—	—

† includes non-revenue earning traffic

Source

MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas New Delhi Ministry of Petroleum and Natural Gas

Table 14

Sales/consumption of petroleum products (thousand tonnes). 1975/76 to April–December 1998

Products	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998* *
Light distillates												
Liquefied petroleum gas	336	405	1241	2415	2650	2866	3113	3434	3849	4184	4606	3619
Motor gasoline	1275	1522	2275	3545	3573	3595	3834	4141	4679	4955	5153	4114
Naphtha	1836	2325	3106	3446	3461	3382	3191	3400	3669	4015	4754	4471
Others	149	136	154	395	431	467	432	662	947	1230	1280	669
Total	**3596**	**4388**	**6776**	**9801**	**10115**	**10310**	**10570**	**11637**	**13144**	**14384**	**15793**	**12873**
Middle distillates												
Kerosene	3104	4228	6229	8423	8377	8478	8704	8964	9317	9646	9869	7931
Aviation turbine fuel	897	1125	1453	1677	1559	1565	1741	1903	2082	2158	2118	1583
High speed diesel	6595	10345	14886	21139	22680	24293	25878	28261	32254	35014	36218	27631
Light diesel oil	878	1122	1123	1506	1462	1407	1370	1369	1311	1223	1237	951
Others	179	236	257	361	326	409	453	479	495	498	467	376
Total	**11653**	**17056**	**23948**	**33106**	**34404**	**36152**	**38146**	**40976**	**45459**	**48544**	**49909**	**38472**
Heavy ends												
Furnace oil	4279	5406	3806	4462	4937	5273	5026	5837	6496	6534	6489	4986
Low sulphur heavy stock/hot heavy stock	1502	2067	4094	4524	4265	3994	4166	4052	4189	4313	4471	3300
Lube oils/greases	441	593	700	892	932	846	688	668	711	705	842	626
Bitumen	690	1064	1126	1581	1706	1823	1824	1939	2005	2273	2164	1671
Petroleum coke	151	137	163	290	266	152	132	197	319	276	194	236
Others	135	185	259	379	349	352	260	180	195	195	214	155
Total	**7198**	**9452**	**10148**	**12128**	**12455**	**12440**	**12096**	**12873**	**13915**	**14296**	**14374**	**10974**
Imports by private parties	–	–	–	–	–	–	–	**1886**	**2152**	**1944**	**4452**	**4208**
Grand total	**22447**	**30896**	**40872**	**55035**	**56974**	**58902**	**60812**	**67373**	**74670**	**79168**	**84528**	**66527**

* April–December

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas New Delhi Ministry of Petroleum and Natural Gas

3 MoPNG 1999 Annual Report 1998/99 New Delhi. Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (sales and consumption)]

Table 15

Average annual compound growth rates of consumption of petroleum products (%)

Product	*Sixth Plan (1980–85)*	*Seventh Plan (1985–90)*	*Eighth Plan (1992–97)*	*Annual Plan (1996–97)*	*Annual Plan (1997–98)**
Liquefied petroleum gas	18.4	18.9	9.2	8.7	10.1
Motor spirit	6.9	10.9	6.4	5.9	4.0
Naphtha	5.3	1.4	2.2	13.4	17.5
Others	1.2	14.2	23.6	16.2	–6.2
Light distillates	7.2	8.3	6.9	9.4	9.8
Aviation turbine fuel	3.2	5.8	6.2	3.4	–1.9
Superior kerosene oil	9.0	6.7	2.6	3.5	2.3
High speed diesel	6.9	8.6	8.6	8.6	3.4
Light diesel oil	–1.1	4.4	–4.1	–6.7	1.1
Others	0.2	3.0	9.1	1.5	–6.0
Middle distillates	6.6	7.7	6.7	6.8	2.8
Lubes	3.2	6.9	0.1	–0.9	19.4
Fuel oil/low sulphur heavy stock	2.3	2.1	2.7	1.5	1.0
Bitumen	–2.6	12.6	7.2	13.4	–4.8
Others	5.5	8.5	–3.3	–8.2	–13.4
Heavy ends	2.0	4.0	2.5	2.7	0.5
Total consumption	5.4	6.9	5.9	6.5	3.7

provisional

Source

MoPNG. 1998. Basic Statistics on Indian Petroleum & Natural Gas New Delhi. Ministry of Petroleum and Natural Gas.

Table 16

Consumption (thousand tonnes) of major petroleum products by state and union territory, including international bunkers· 1995/96

State/union territory others	Naphtha	Liquefied petroleum gas	Motor spirit	Superior kerosene oil	Aviation turbine fuel	High speed diesel	Light diesel oil	Furnace oil	Low sulphur heavy stock/hot heavy stock	Lubes/ greases	Others	Total
State												
Andhra Pradesh	92	289	314	614	41	2867	34	261	90	49	196	4847
Arunachal Pradesh	—	4	16	12	2	59	1	—	—	2	—	96
Assam	26	62	55	266	51	353	3	84	28	19	77	1024
Bihar	90	114	156	609	5	1567	138	405	82	46	221	3433
Delhi	2	309	436	240	643	1153	45	55	25	30	110	3048
Goa	288	18	32	28	28	170	7	161	—	5	12	749
Gujarat	572	300	393	813	48	2403	197	491	1707	46	725	7695
Haryana	—	118	150	165	25	1361	54	328	150	24	84	2459
Himachal Pradesh	—	28	26	37	—	170	4	7	8	3	14	297
Jammu and Kashmir	—	34	46	125	11	196	6	2	1	5	28	454
Karnataka	122	194	316	494	78	1777	26	368	127	34	84	3620
Kerala	170	134	206	292	53	1180	9	181	203	25	181	2634
Madhya Pradesh	—	185	216	483	25	1923	33	293	59	39	261	3517
Maharashtra	482	677	722	1545	613	3821	329	11261	987	144	702	11283
Meghalaya	—	5	18	17	—	89	—	—	—	1	8	138
Manipur	—	7	9	22	2	24	—	—	—	1	19	84
Mizoram	—	5	6	7	—	18	—	—	—	—	1	37
Nagaland	—	5	11	13	1	29	—	—	—	1	1	61
Orissa	124	40	72	212	11	631	32	327	3	18	84	1554
Punjab	50	168	313	353	56	1765	50	655	245	27	127	3809
Rajasthan	278	141	197	331	51	2148	48	106	133	23	153	3609
Sikkim	—	2	5	10	—	8	1	1	—	—	2	29
Tamil Nadu	514	322	338	683	108	2869	46	884	201	53	267	6285
Tripura	—	5	6	23	3	33	—	—	—	1	8	79
Uttar Pradesh	783	456	396	1095	98	3714	102	335	137	54	294	7464
West Bengal	75	195	159	777	104	1660	129	248	—	55	274	3676
Total	**3668**	**3817**	**4614**	**9266**	**2057**	**31988**	**1294**	**6453**	**4186**	**705**	**3933**	**71981**
Union territory												
Andaman and Nicobar Islands	—	1	2	5	3	45	—	—	—	1	—	57
Chandigarh	—	20	42	20	22	53	5	12	3	2	17	196
Dadra and Nagar Haveli	—	—	4	3	—	39	4	2	—		2	54
Daman and Diu	—	1	3	3	—	9	1	2	—	—	2	21
Lakshadweep	—	—	—	—	—	—	—	—	—	—	—	—
Pondicherry	1	8	12	15	—	106	3	24	—	3	10	182
Total	**1**	**30**	**63**	**46**	**25**	**252**	**13**	**40**	**3**	**6**	**31**	**510**
Bhutan	—	2	2	5	—	14	—	3	—	—	1	27
Nepal	—	—	—	—	—	—	—	—	—	—	—	—
Total	**—**	**2**	**2**	**5**	**—**	**14**	**Neg**	**3**	**—**	**Neg**	**1**	**27**
Grand total	**3669**	**3849**	**4679**	**9317**	**2082**	**32254**	**1307**	**6496**	**4189**	**711**	**3965**	**72518**

Source
MoPNG. Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE+ [Section· Oil and gas (exports and imports)]

Table 17

Offtake (million cubic metres) of natural gas by industry: 1975/76 to 1997/98

Industry	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96* †	*1996/97*	*1997/98*
Energy purposes											
Power generation	366	492	1299	3634	4774	4967	4785	5229	6836	6935	8067
Industrial fuel	143	163	223	827	766	1450	1794	1927	2301	2631	1719
Tea plantation	33	45	78	89	108	105	121	134	111	130	—
Domestic fuel	13	14	21	50	72	187	189	190	178	184	—
Captive use/Liquefied petroleum gas	104	176	795	1775	2165	1916	2277	2230	589	618	920
Total	**659**	**890**	**2416**	**6375**	**7885**	**8625**	**9166**	**9710**	**10015**	**10498**	**10705**
Non-energy purposes											
Fertilizer industry	463	611	2500	5612	5509	6672	6499	6936	7602	7625	8753
Petrochemicals	0	5	10	409	531	578	494	520	474	509	—
Others	2	16	24	370	516	241	181	173	—	—	—
Total	**465**	**632**	**2534**	**6391**	**6556**	**7491**	**7174**	**7629**	**8076**	**8134**	**8753**
Grand total	**1124**	**1522**	**4950**	**12766**	**14441**	**16116**	**16340**	**17339**	**18091**	**18632**	**19458**

excludes some sales by the Oil and natural gas corporation Limited.

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2. MoPNG. 1997. Basic Statistics on Indian Petroleum & Natural Gas New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (sales and consumption)]

Table 18

Subsidies on major petroleum products and subsidies by the central government (million rupees): 1991/92 to 1997/98

Product	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *
Kerosene – domestic use	23640	33040	37730	37400	41900	65400	58300
High speed diesel	480	1200	5750	4300	21800	80900	—
Liquefied petroleum gas – packed – domestic use	8770	11760	12610	14100	16300	22200	15200
Naphtha/Fuel oil/Low sulphur heavy stock – fertilizer use	6610	8150	7720	8500	12000	15200	—
Bitumen – packed	1250	1520	1260	1100	1200	2000	—
Paraffin wax	1000	1190	890	200	400	300	—
Total	**41750**	**56860**	**65960**	**65600**	**93600**	**186000**	**73500**
Total central government subsidies	122530	119950	126820	129320	133720	161250	196440
POL products	41750	56860	65960	65600	93600	186000	73500
Total subsidy	164280	176810	192780	194920	227320	347250	269940
POL subsidy as percentage of total subsidy	25.41	32.16	34.22	33.65	41.18	53.56	27.23

provisional

these do not form part of the government budget

Source

MoPNG 1998. Basic statistics on Indian Petroleum & Natural Gas New Delhi. Ministry of Petroleum and Natural Gas.

Table 19

Prices (rupees per tonne) of indigenous crude oil with rates of royalty and oil development cess: 16 December 1977 to 1 April 1996

	Onshore crude oil			*Offshore crude oil*		
Effective date	*Royalty*	*Cess*	*Price (inclusive of royalty and cess)*	*Royalty*	*Cess*	*Price (inclusive of royalty and cess)*
16 December 1977	42	60	305.4	42	60	433.7
1 April 1981	61	60	324.4	61	60	452.7
11 July 1981	61	100	1182.0	61	100	1182.0
15 February 1983	61	300	1382.0	61	300	1382.0
1 April 1984	192	300	1513.0	192	300	1513.0
1 March 1987	192	600	1813.0	192	600	1813.0
1 April 1987	314	600	1935.0	314	600	1935.0
1 February 1989	314	900	2235.0	314	900	2235.0
1 April 1990	481	900	2402.0	481	900	2402.0
16 September 1992	481	900	2887.0	481	900	2887.0
1 April 1993	528	900	3169.0	528	900	3169.0
1 April 1994	528	900	3169.0	528	900	3169.0
1 April 1995	528	900	3169.0	528	900	3169.0
* 1 April 1996	578	900	3469.0	578	900	3469.0

* provisional

Source

MoPNG Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 20

Development of spot prices of key Organization of Petroleum Exporting Countries' crudes (dollars per barrel): 1995 to 1998

Month	*Arab light*	*Arab heavy*	*Iranian light*	*Kuwait (export)*	*Saharan blend*	*Dubai*
1995						
January	16.76	15.24	16.33	15.71	16.99	16.03
February	17.29	15.81	16.82	16.24	17.36	16.63
March	17.02	15.92	16.62	15.97	17.24	16.30
April	18.03	17.08	17.56	17.38	18.87	17.38
May	17.82	16.93	17.22	17.15	18.70	17.29
June	16.79	15.74	16.05	15.74	17.64	16.19
July	15.67	14.62	14.89	15.02	16.11	15.03
August	15.96	14.61	15.34	15.30	16.37	15.40
September	16.15	15.00	15.61	15.35	17.24	15.55
October	15.54	14.38	15.01	14.74	16.70	1.93
November	16.30	15.15	15.69	15.50	17.32	15.70
December	17.61	16.61	16.97	16.81	18.55	16.98
1996						
January	17.39	16.24	16.92	16.51	18.66	16.59
February	17.34	16.19	16.51	15.96	18.66	15.93
March	19.10	17.98	17.26	16.79	20.61	16.95
April	20.67	19.37	18.11	17.56	21.48	17.58
May	18.85	17.55	17.58	16.96	19.76	16.91
June	18.02	16.72	17.51	17.08	18.85	17.24
July	18.66	16.96	18.32	17.47	20.10	17.76
August	19.53	17.71	19.14	18.26	21.13	18.64
September	21.12	19.37	20.72	19.87	23.09	20.30
October	22.54	20.87	21.94	21.34	24.79	21.70
November	21.91	20.26	21.24	20.73	23.45	20.89
December	23.03	21.15	21.41	21.69	24.68	21.82
1997						
January	22.58	20.68	22.26	21.37	24.18	21.35
February	20.03	18.13	19.81	18.88	21.80	18.84
March	19.11	17.25	18.89	18.04	19.66	18.09
April	17.87	16.02	17.69	16.77	17.95	16.77
May	19.35	17.50	18.93	18.25	19.65	18.60
June	17.95	16.20	17.51	16.95	18.09	17.34
July	17.85	16.22	17.25	16.93	19.01	18.05
August	17.79	16.59	17.17	17.09	19.26	19.20
September	18.21	17.11	17.48	17.55	19.19	18.58
October	19.42	18.52	18.82	18.72	20.36	19.20
November	18.81	17.76	18.22	18.19	19.80	18.58
December	16.58	15.08	16.03	15.98	17.70	16.30
1998						
January	13.61	12.11	13.40	12.80	15.56	13.41
February	12.80	11.10	12.34	11.69	14.48	12.41
March	11.67	9.77	11.31	10.61	13.49	11.53
April	12.18	10.53	11.98	10.99	13.82	12.23
May	12.73	11.33	12.53	11.55	14.55	12.75
June	11.88	10.48	11.68	10.73	12.06	11.80
July	11.87	10.47	11.67	10.97	12.47	12.11
August	12.48	11.36	12.28	11.33	12.41	12.25
September	13.17	12.17	12.97	12.39	13.73	13.08
October	12.72	11.82	12.52	12.01	12.83	12.69
November	11.92	11.07	11.72	11.24	11.25	11.96
December	9.90	9.15	9.80	9.31	10.23	10.11

Note

Figures are weekly averages.

Source

OPEC. Monthly Bulletin (various issues) Vienna Organization of Petroleum Exporting Countries

Table 21

Realization of excise and customs duties from crude oil and petroleum products (million rupees): 1986/87 to 1997/98

Products	1986/87	1989/90	1990/91	1992/93	1994/95	1995/96	1996/97	1997/98 *
Excise duties								
Motor spirit	8140	12000	12020	12870	15240	16310	21170	26770
Kerosene oil	2330	2680	2550	2390	3060	2580	6470	4430
Refined diesel oil	5960	7310	6930	7430	11810	11550	19620	22940
Diesel oil	270	380	350	340	1070	800	12300	1460
Furnace oil	370	530	490	640	1840	1460	2890	3720
POL products (no.)	2770	3590	4210	4270	5840	7330	8810	16000
Petroleum gases	500	660	660	790	2000	2760	3820	3950
Cess on crude oil	9800	29470	27570	21690	26100	28800	26750	27050
Sub-total	**30140**	**56620**	**54780**	**50420**	**66960**	**71590**	**90760**	**106320**
Customs duties								
Crude petroleum	8570	21490	31460	40530	34640	40520	57400	44950
Petroleum products	2180	2820	5550	12270	27450	44010	57840	44570
Sub-total	**10750**	**24310**	**37010**	**52800**	**62090**	**84530**	**115240**	**89520**
Grand total	**40890**	**80930**	**91790**	**103220**	**129050**	**156120**	**206000**	**195840**

* revised estimates

Source

MoPNG. 1998 Basic Statistics on Indian Petroleum & Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas.

Table 22

Development of (ex-storage point) basic ceiling selling prices (rupees per selling unit) of petroleum products: 1981 to June 1999

Product	Selling unit	11 July 1981	17 March 1985	20 March 1990	15 October 1990	25 July 1991	16 September 1992	2 February 1994	1 March 1994 to 1 March 1995 *	7 July 1996	2 September 1997	17 January 1998	1 April 1998	June 1999
Aviation turbine fuel (domestic)	Kilolitres	3872	4740	6560	8200	9840	10838	10838	9852	10838	10838	10838	10838	10759
Motor spirit 83/87	Kilolitres	5438 ‡	6369	8944	11180	13416	14413	15413	12844	16055	17055	17055	17055	15399
Motor spirit 93	Kilolitres	5593	6421	10944	13680	16416	17413	18413	15344	19180	20180	20180	20180	18239
High speed diesel oil	Kilolitres	2650	3078 §	3634	4542	4542	5539	6289	5717	6575	8375	8375	7837	6882
Superior kerosene oil (domestic)	Kilolitres	1545	1822 §	1957	2446	2202	2202	2202	2001	2001	2001	2001	2001	2001
Light diesel oil	Kilolitres	2506	3054	3054	3817	4199	5396	6146	5588	7264	7264	7264	7201	
Furnace oil														
For non-fertilizer	Kilolitres	2424	2903	2903	3629	3992	4989	4989	4535	5896	5143	5143	4801	—
† For fertilizer	Kilolitres	1274	1320	1320	1650	1815	2812	2812	2812	3656	5143	5143	4801	—
Low sulphur heavy stock														
† For fertilizer	Tonnes	—	—	1349	1686	1854	2852	2852	2852	3707	6089	6089	5071	—
For non-fertilizer	Tonnes	—	—	2769	3461	3807	4804	4804	4804	6245	6089	6089	5071	—
Bitumen straight grade														
Bulk	Tonnes	2323	2575	2575	3219	3540	4538	4538	4125	5363	5600	5600	5600	—
Packed	Tonnes	2608	3100	3100	3875	4262	5259	5259	4781	6216	7050	7050	7050	—
Naphtha														
† For non-fertilizer	Tonnes	2792	3211	3211	4014	4415	6076	6076	6076	6683	7624	7444	7072	—
† For fertilizer	Tonnes	1723	1982	1982	2478	2726	3723	3723	3723	4840	7624	7444	7072	—
Liquefied petroleum gas (packed)														
Domestic	Tonnes	2634	3029	3449	3449	4139	5136	5840	5309	6902	7958	7958	7958	8733
# Non-domestic (essential)	Tonnes	2928	3978	5001	6251	6877	12588	12588	11443	—	—	—	—	—
# Non-domestic (non-essential)	Tonnes	—	5128	6151	7689	8458	14169	14169	12881	13900	14303	14303	10015	—

* w.e f. 1 March 1994, customs and excise duties on all petroleum products were on ad valorem basis with only two rates. Motor spirit and coal tar would attract 20% duty
All other petroleum products would be charged at central excise duty at 10%

† prices are exclusive of customs and excise duties

‡ *with the introduction of motor spirit 87, the price of the product was increased to 5538 rupees per kilolitre* w.e.f 1 September 1983

§ effective 26 March 1985

# w.e.f. 17 May 1995, the two categories under non-domestic liquefied petroleum gas (packed) for essential and non-essential have been merged together with a price of 12881 rupees per million tonne.

Notes

1 Prices have been rounded off to the nearest rupee.

2 *With effect from* 1 October 1986, jute batching oil, special boiling point spirit 64/69, hexane, mineral turpentine oil-140/205, and mineral turpentine oil have been kept outside the pricing scheme, low sulphur heavy stock has been brought under the pricing scheme

Sources

1. MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi· Economics and Statistics Division, Ministry of Petroleum and Natural Gas
2. MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas New Delhi· Ministry of Petroleum and Natural Gas

For more details, please see TEDDY ONLINE + [Section. Oil and gas (prices)]

Table 23

Retail selling price of selected petroleum products in metropolitan cities and towns 1996 to 1998

City/town	MS-87 (rupees per litre)	High speed diesel (rupees per litre)	Superior kerosene oil (rupees per litre)	Light diesel oil (rupees per kilolitre) *	Furnace oil (rupees per kilolitre) *	Liquefied petroleum gas (rupees per 14.2 kg cylinder)	Aviation turbine fuel: Domestic airlines (rupees per kilolitre) ‡	Aviation turbine fuel: International airlines (dollars per kilolitre)
2 January 1996								
Mumbai	19 26	7 84	2 55	6267 59	5104.22	94 37	11134 82	278.96
Calcutta	17 68	7 25	2 80	6251 08	5091.23	106.99	11074 96	296.40
Delhi	16 95	6.99	2 57	6287 47	5163.46	93.78	10999.50	251.07
Chennai	19 98	7 80	2 80	6321 80	5155 63	98 05	11273.25	288 25
Kanpur	18 12	7 69	2 85	6487 14	— †	98 87	11224.20	—
3 July 1996								
Mumbai	24 03	9 00	2 55	8123 61	6612 40	120.90	12248 30	259 94
Calcutta	22 05	8.32	2 80	8103 19	6695 68	136 66	12180 42	276.20
Delhi	21 13	8 02	2 57	8133 86	6662.60	119 95	12088.70	233 95
Chennai	24 91	8 95	2 80	8145 10	6668 95	123.81	12400.58	268 61
Kanpur	22 53	8.79	2.85	8331.53	— †	126.24	12312 65	—
1 April 1997								
Mumbai	24 03	9 00	2 55	8123 61	6612.40	118 60	15922.79	315.42
Calcutta	22 05	8.32	2.80	8103 19	6695 68	136 65	15530.04	335.13
Delhi	21.13	8 02	2 58	8131 60	6659 63	119 95	13073.67	283.88
Chennai	24 91	8.86	2 80	8183 24	6668 95	124 10	15376.72	325.93
Kanpur	22.40	8.65	2 80	8182.00	— †	126 25	13860 60	—
2 September 1997								
Mumbai	25.79	11 53	2 55	8123 61	5809.68	137 85	15922 79	315.42
Calcutta	23.55	10.63	2 80	8103 19	5796 59	158 55	15682.30	335.13
Delhi	23.84	10.34	2.56	8131 60	5831.04	136.00	13073.67	283.88
Chennai	26.79	11 39	2 81	8183 24	5955.98	145.05	15376.72	325 93
Kanpur	23 77	10 97	2 80	8182 00	—	144 40	13860 60	—
1 January 1998								
Mumbai	25 79	11 58	2 55	8123 61	5520 83	137.85	15922 79	—
Calcutta	23 54	10 08	3 05	8103 19	5505 96	158 55	15682.30	—
Delhi	22 84	10.39	2 56	8131 60	5572 63	136 00	13073.67	—
Chennai	26 79	11 45	2 80	8183 24	5685 25	145 05	15376.72	—
Kanpur	23 76	11 06	2 79	8182 00	— †	144.38	13860 60	—
1 April 1998								
Mumbai	25 79	11 43	2 55	8420 62	5741 49	137 85	15922.79	—
Calcutta	23 54	10 55	3 05	8401 64	5669 86	158 55	15682 30	—
Delhi	22 84	10 25	2 56	8440 01	5717 72	136.00	13073 67	—
Chennai	26 79	11 30	2 80	8482 96	5833 95	145 05	15376.72	—
Kanpur	23 76	10 85	2 79	8508 67	— †	144.38	13860 60	—
3 June 1998								
Mumbai	27 07	11 43	2 55	8420 62	5741 49	137 85	15922 79	—
Calcutta	24 70	10 55	3 05	8401 64	5669 86	158.55	15682.30	—
Delhi	23 94	10 25	2 56	8440 01	5717 72	136.00	13073.67	—
Chennai	28 14	11 30	2 80	8482.96	5833 95	145 05	15376.72	—
Kanpur	24 90	10 85	2.79	8508 67	— †	144.38	13860.60	—

* no retail sale, ex-depot rates exclusive of sales tax

† no storage facility

‡ excluding sales tax and local levies

Sources

1 MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas. New Delhi Ministry of Petroleum and Natural Gas

Table 24

Quarterly gas prices with effect from October 1997

Quarter	*Relevant quarter for fuel oil prices*	*Average fuel oil price (dollar per tonne)*	*Linkage (%)*	*Consumer price (rupees per thousand cubic metres)*
October–December 1997	June–August 1997	98.61	55	2150
January–March 1998	September–November 1997	108.96	55	2411
April–June 1998	December 1997–February 1998	77.07	65	2271
July–September 1998	March–May 1998	75.42	65	2246
October–December 1998	June–August 1998	65.53	65	2222
January–March 1999	September–November 1998	72.80	65	2215
April–June 1999	December–February 1999	62.28	75	2167

Quarter	*Total quantity ONGCL (million cubic metre)*	*Producer price (rupees per thousand cubic metres)*	*Linkage (%)*	*North–Eastern Price (rupees per thousand cubic metres)*
October–December 1997	4553.91	1802	30	1200
January–March 1998	4541.90	2004	30	1315
April–June 1998	4570.03	1833	40	1250
July–September 1998	4614.98	1834	40	1307
October–December 1998	4748.90	1834	40	1200
January–March 1999	4204.58	1834	40	1274
April–June 1999	3901.36	1834	45	1224

Source

MoPNG. 1999. New Delhi: Ministry of Petroleum and Natural Gas

Table 25

Plan expenditure and the share of oil and gas

Five-Year Plan	*Period*	*Plan expenditure (million rupees)* ‡	*Oil and gas (million rupees)*	*Total energy (million rupees)* *
First	1951–56	19600	0	3861.2 (19.7)
Second	1956–61	26700	213.6 (0.8)	3310.8 (12.4)
Third	1961–66	85800	2230.8 (2.6)	15873.0 (18.5)
Fourth	1969–74	157800	2998.2 (1 9)	33453 6 (21.2)
Fifth	1974–79	394300	14194.8 (3.6)	99363.6 (25.2)
Sixth	1980–85	1092900	85246.2 (7.8)	307104.9 (28.1)
Seventh	1985–90	2202200	160760.6 (7.3)	621020.4 (28.2)
† Eighth	1992–97	4341000	238755.0 (5 5)	1150365.0 (26 5)

* total energy includes power, coal, oil and gas, and non-renewable sources of energy
† outlay
‡ expenditure at current price at the base year of the respective plants

Note

Figures in parentheses are percentages

Source

PC. 1999. Ninth Five-Year Plan 1997–2002. Volume II. Thematic Issues and Sectoral Programmes. New Delhi. Planning Commission, Government of India

Table 26

Growth of Indian petroleum industry at a glance

	Unit	1980/81	1985/86	1990/91	1995/96	1996/97	1997/98 *
Unit value of crude oil imports (gross)	Rupees per million tonne	2061	2435	2956	4212	5467	4609
India's total exports							
POL imports as percentage of India's total exports	Million rupees	67110	108950	325530	1 063530	1 188170	—
Gross imports	Percentage	79	46	33	24	29	—
Net imports	Percentage	78	40	30	22	27	—
Contribution of oil sector to centre/state resources							
Royalty from crude oil	Million rupees	410	3790	20280	16370 †	15500	—
Royalty from gas	Million rupees	30	220	1380	2710	3000	—
Oil development cess	Million rupees	600	8660	27820	27770	26500	—
Excise and customs duties	Million rupees	15700	37680	91790	156120	206000	—
Sales tax	Million rupees	6280	15640	36530	84720	99000	—
Dividend	Million rupees	440	820	1890	6880	7000	—
Corporate tax and others	Million rupees	760	7400	6460	16530 ‡	16000	—
Natural gas							
Gross production	Million cubic metre	2358	8134	17998	22308	22745	24720
Utilization	Million cubic metre	1522	4950	12766	20816	21261	23168

* provisional

† excludes royalty and cess payable by private/joint venture companies

‡ estimated

Source

MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas New Delhi Ministry of Petroleum and Natural Gas

Table 27

International petroleum statistics: 1980 to 1996

Item	Unit	*1980*	*1985*	*1990*	*1994*	*1995*	*1996**
World reserves							
Oil and gas at the year end-R							
Crude oil	BT (billion tonnes)	89	95.2	136.5	137.3	138.3	140.9
of which OPEC	BT	59.7	64.6	105.1	104.7	105.8	107.2
Natural Gas	TCF (trillion cubic feet)	2896	3461	4209	4980	4934	4991
of which OPEC	TCF	1076	1109	1735	2034	2037	2112
World production of oil & gas							
Crude oil-R	Million tonnes	3084	2809	3154	3213	3266	3362
of which OPEC	Million tonnes	1358	833	1188	1319	1326	1363
Natural Gas-R Net	BCM (billion cubic metre)	1448	1692	2037	2087	2128	2231
of which OPEC-R	BCM	87	153	233	264	304	325
World oil refinery							
Refinery capacity	MTPA (million tonnes per annum)	4031	3623	3748	3756	3819	3866
Crude throughput	MTPA	2946	2750	3093	3088	3147	3228
† **World oil consumption**							
World total	MT (million tonnes)	3024	2809	3140	3189	3235	3313
Main consuming areas	MT	1468	1299	1423	1477	1477	1509
Consumption in main areas as percent of world	Percentage	48.5	46.2	45.3	46.3	45.7	45.5
World imports/exports							
Crude oil	MT	1317	887	1188	1376	1403	1449
POL products	MT	271	302	363	378	385	431
Total	MT	**1588**	**1189**	**1551**	**1754**	**1788**	**1880**
Exports of crude oil							
POL from OPEC							
Crude oil	MT	1122	525	797	895	898	908
POL products	MT	98	117	176	187	205	213
Total	MT	**1220**	**642**	**973**	**1082**	**1103**	**1121**
World primary energy consumption							
Oil	MTOE (million tonnes of oil equivalent)	3024	2807	3121	3189	3235	3313
Natural gas	MTOE	1286	1479	1760	1838	1884	1972
Coal	MTOE	1816	2083	2230	2185	2205	2257
Hydroelectric	MTOE	432	170	183	206	216	218
Nuclear energy	MTOE	172	369	511	573	598	621
Total	MTOE	**6730**	**6908**	**7805**	**7990**	**8137**	**8380**

OPEC - Organization of Petroleum Exporting Countries

* provisional

† includes USA, Germany, France, Italy, UK, and Japan

Note

R - Based on BP conversion factor

Source

MoPNG 1998 Basic Statistics on Indian Petroleum & Natural Gas New Delhi
Ministry of Petroleum and Natural Gas

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Overview

The total installed capacity in India as on 31 March 1999 was 93 253 MW, consisting of 22 443 MW hydro, 67 561 MW thermal, 2225 MW nuclear, and 1024 MW wind (Table 4). A capacity-addition programme of 3299 MW was planned for the year 1998/99. Against this figure, 3112 MW or about 94% of the targeted capacity addition was achieved till 1 January 1999 (MoP 1999).

The Ninth Five-Year Plan envisages a total capacity addition of 40 245 MW, comprising 9820 MW hydro, 29 546 MW thermal, and 880 MW nuclear power. The proposed additions by sector and region are provided in Tables I and II, respectively. According to the mid-term review of the Ninth Five-Year Plan, only 70% of the targeted capacity addition is expected to achieve by 2002. While the central sector is expected to add 9760 MW, the state sector is expected to add 9860 MW. The private sector is expected to add 8495 MW as against the targeted capacity addition.

Table I Capacity addition by sector during the Ninth Five-Year Plan (MW)

Sector	*Hydro*	*Thermal*	*Nuclear*	*Total*
Centre	3455.0	7574.0	880	11909.0
State	5814.7	4933.0	0	10747.7
Private	550.0	17038.5	0	17588.5
Total	9819.7	29545.5	880	40245.2

Source MoP (1999)

The PLF (plant load factor) for each sector for the past six years is illustrated in Figure 1.

Table II Capacity addition by region during the Ninth Five-Year Plan (MW)

Region	*Hydro*	*Thermal*	*Nuclear*	*Total*
North	4177.0	3360.0	440	7977.0
West	2212.5	8361.7	0	10574.2
South	1824.5	7684.3	440	9948.8
East	918.5	3890.0	0	4808.8
North-east	682.0	229.5	0	911.5
Andaman and Nicobar Islands	5.2	20.0	0	25.2
Total	9819.7	23545.0	880	34245.2
Liquid fuel	0	6000	0	6000.0
All India	9819.7	29545.5	880	40245.2
Total planned capacity as on 31 March 2002	31477.7	90702.5	3105	125285.2

Source MoP (1999)

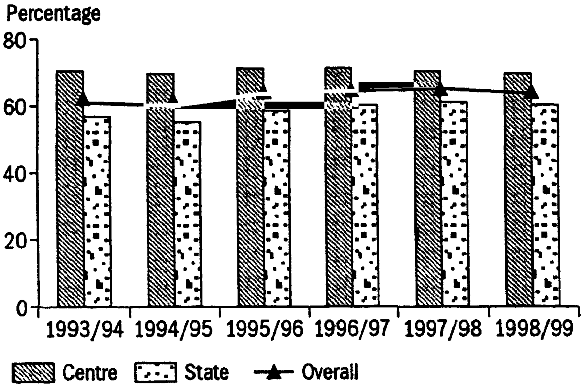

Figure 1 Plant load factor by sector
Source MoP (1999)

The actual all-India PLF during April 1998–January 1999 was 63.3%, which was 1% less than the target of 64.3% for this period. Even though the average PLF has been higher for the central and private sectors, the state sector has registered the maximum improvement in PLF since 1993/94. While comparing the PLF across regions, it is observed that the western and southern regions have a higher value compared to the eastern and north-eastern regions and the national average (Table 5). The low PLF in some cases could be a result of the poor quality of coal, age, and size of units; outdated equipment; and outage of units (Planning Commission 1997).

The overall power generation in India has increased from 287 billion units in 1991/92 to 420 billion units in 1997/98 (MoP 1998). The generation target for 1998/99 is 450 billion units. India is expected to continue to depend on coal-based thermal power generation for the next few years. Hence a balanced development of this form of power generation is necessary, keeping in view the availability of coal, transportation constraints, and environmental issues. In view of the shortfall in the availability of indigenous coal for power generation, non-coking coal imports and multi-fuel generations are being considered as feasible options. Privatization of mines and captive mining are expected to increase the production of coal. In addition, efforts are being made to develop lignite-based power stations in Tamil Nadu, Pondicherry, Rajasthan, and Gujarat.

Capacity addition

Some of the policies that need to be developed to add capacity in the future are discussed in the sections below.

Mega power projects

The guidelines for setting up mega power projects were initially issued in November 1995. Accordingly, power projects of 1500 MW capacity or more and supplying power to more than one state were defined as mega power projects. The government, however, proposes to revise the mega power policy setting the benchmark of 1000 MW for availing duty-free incentives. Some of the provisions of the revised policy are as follows.

- Interstate and inter-regional mega power projects are proposed to be set up both in the public and private sectors.
- The SIG (Standing Independent Group), which had been constituted by the government in November 1997 to establish the parameters for the negotiation of large power projects, would initially be the apex body to oversee the implementation of mega private power projects.
- The principles of competitive bidding would be adhered to as far as possible, while obtaining tariff offers.
- To ensure that domestic bidders are not affected adversely, a price preference of 15% would be given to the projects under the public sector, and deemed export benefits under the export–import policy would be given to domestic bidders from both public and private sectors.
- A PTC (Power Trading Corporation) is to be formulated under the new policy. A letter of credit and recourse to the state's share of central plan allocations would make the PTC secure.
- The necessary precondition for the PTC would be that the state should constitute a regulatory commission with full powers to fix tariffs as envisaged in the Electricity Regulatory Commissions Act, 1998, and privatize distribution in cities with a population exceeding one million.
- The import of capital equipment for these projects would be free of customs duty.
- The income-tax holiday regime would continue for a block of 10 years within the first 15 years.
- The state governments are requested to exempt supplies to mega power plants from sales tax and local levies.

It is expected that 15 000–20 000 MW of capacity addition would be achieved through this policy by the end of the Tenth Plan period, with the most competitive tariffs payable by the SEBs (state electricity boards) and consequently by the consumers.

Liquid fuel-based power projects

In view of the long gestation period for coal/lignite, and hydroelectric projects, it was recognized that for a quick capacity addition, it would be an economically viable option to set up liquid fuel-based power projects. A few combustion turbine-based combined cycle plants using liquid/gas fuels are being considered in areas where the transportation of coal is either costly or infeasible. The use of naphtha-based power plants would be confined to only those power producers who have been allocated liquid-fuel linkages under the provisions of the liquid-fuel policy as this option for power generation is both uneconomical and short-sighted.

Modifications to the liquid-fuel policy were made recently on the basis of requests for providing additional linkages for new projects and for putting up power projects based on non-traditional fuels such as condensates and orimulsion. The following decisions were taken in July 1998.

- The existing ceiling of 12 000 MW allocated to various states would apply only to naphtha. This would be in addition to the FO/LSHS (fuel oil / low sulphur heavy stock) linkages already given.
- States would, therefore, be free to contract for new projects based on FO beyond the existing linkage.
- Taking into account the environmental stipulations, it would be mandatory for FO-based power plants to use the IGCC (integrated gasification combined cycle) technology, or any other technology that would ensure sulphur emissions within the stipulated levels.
- The LSHS is already on Open Generalized Licence and this facility would be extended to other non-traditional fuels such as orimulsion depending upon actual user conditions.
- There would be no obligation for oil public sector undertakings to give fresh linkages for any new projects, except naphtha-based projects within a ceiling 12 000 MW and projects based on other fuels for which linkages have already been issued.
- High speed diesel would be permitted for power generation only in inaccessible and isolated areas, where small diesel-based capacities are sought to be set up and other fuels are not feasible.

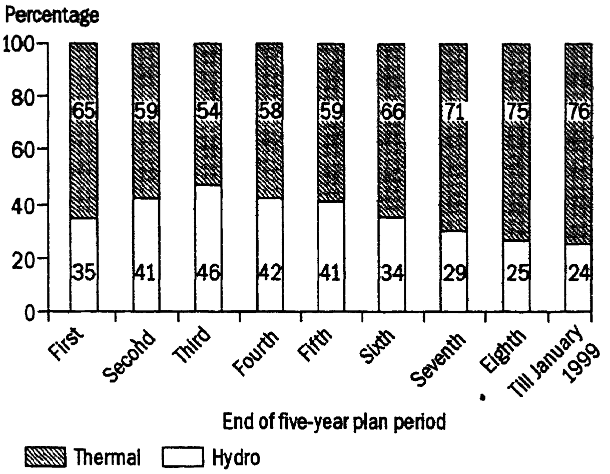

Figure 2 Installed hydrothermal capacity mix of the five-year plans (%)
Source MoP (1999)

Hydroelectric projects

The Ninth Plan envisages an addition of 9820 MW of hydro capacity. The installed generation mix of the five-year plans is illustrated in Figure 2. The capacity addition is expected to be achieved through the prioritization of hydroelectric power development and conducive institutional and financial arrangements. Inadequate hydel support in the western and eastern regions (Table 14) is affecting the performance of the thermal plants adversely, as they provide the peaking power, thus having to back down during non-peaking hours.

The NHPC (National Hydroelectric Power Corporation) is one of the important players in the development of hydroelectric power in the central sector. In addition to the ongoing hydro projects, the NHPC is also examining new turnkey projects and small and mini-hydro projects, which are expected to rectify the prevailing imbalance in the hydrothermal mix. The North-Eastern Electric Power Corporation has also taken up several projects in the north-eastern region, which has an enormous potential for hydropower estimated at 48 000 MW (MoP 1999). The NTPC (National Thermal Power Corporation) has also initiated action for the development of hydro projects in the upper reaches of Uttar Pradesh.

Development of water resources of the rivers flowing through India, Nepal, and Bhutan has been under discussion. India has been providing technical and financial assistance to Nepal in the development of hydropower potential in exchange for surplus power. Three major water resource projects in Nepal, namely Karnali (1080 MW), Pancheswar (5600 MW), and Saptakoshi (3300 MW), are presently under discussion for mutual benefits. In Bhutan, the 336-MW capacity Chukha hydroelectric project is operating excellently and is an example of cooperation between India and Bhutan. Surplus power is being purchased by India in exchange for the technical and financial assistance provided for the development of the project. The Tala hydroelectric project with a capacity of 1020 MW has been taken up for implementation and has been funded by India in exchange for surplus power. In addition, investigations for Sankosh (4060 MW), Wangchu (900 MW), and Bunakha (180 MW) projects have also been completed.

Nuclear power projects

The current nuclear capacity of 2225 MW constitutes only 2.6% of the total installed capacity. The nuclear power generation capacity has grown at a very slow rate due to paucity of funds. The Nuclear Power Corporation of India has limited internal resources and faces several constraints in mobilizing funds from external sources and the private sector. Greater budgetary allocation is, therefore, required in this sector. In view of private sector participation in thermal and hydro projects, there is a need to explore the possibility of private investments in nuclear generation as well. It is necessary to ensure that the high degree of self-reliance in nuclear power generation is further consolidated, upgraded, and utilized for higher capacity addition.

Transmission and distribution

The development of power generation facilities needs to be matched by the concomitant development of a transmission system for transmitting the generated power to the load centres. It has been established that the transportation of coal is less economical than the transmission of an equivalent amount of electric power over long distances. This has led to the development of pithead-based power generating units with an extensive network of transmission lines for transmitting power to the states.

The regional concept in the power system is giving way to a more integrated approach in the form of a national power grid, which will facilitate transfer of power from regions of surplus to regions of deficit. The 400-kV AC system would be the mainstay of the EHV (extra-high voltage) transmission system in the next 15 years and would be supplemented by a 765-kV AC system and high voltage DC system in certain corridors for bulk power transfer (Table 16).

While SEBs are responsible for developing the T&D (transmission and distribution) system at the state level, the PGCIL (Powergrid Corporation of India Limited) is responsible for developing the central sector transmission system, including setting up the national power grid (Map 6, Appendix II).

Although the regional grids have been inter-connected, paving the way for the formation of the national power grid, further strengthening of the inter-regional and intra-regional grids would be essential to facilitate power exchanges. During 1998/99, all the five regional grids, namely northern, western, southern, eastern, and north-eastern, were operating in parallel. Power transfers between northern and western regions took place over the Vindhyachal–Singrauli HVDC (high voltage direct current) back-to-back link. The southern states of Tamil Nadu and Kerala; Madhya Pradesh in the central region; Goa, Daman, and Diu in the western region; and Assam in the north-eastern region received considerable assistance from the NTPC stations in the eastern region.

The growth in the T&D network has resulted in an increase in the number of towns and villages electrified as indicated in Tables 18 and 21. All urban areas and over 500 000 villages of a total of 700 000 villages have access to electricity. The total number of pumpsets energized as on 30 November 1998 was about 11.9 million, which led to a growth in agricultural production. However, about 8 million pumpsets still remain to be energized.

Transmission and distribution losses

Transmission and distribution losses increased from 20% to 21% during 1992/93 to 1998/99 (Table 17). There are considerable interstate variations in the magnitude of the losses. The studies undertaken in Orissa for the restructuring exercise indicated T&D losses of the order of 47%. A more realistic assessment and reduction of T&D losses in a time-bound manner in all the other states is therefore required. An improvement in the PLF, coupled with reduction in T&D losses, will reduce the requirement of additional power generating capacity.

Investments

Ninth Five-Year Plan outlay

An outlay of 1245.264 billion rupees in the central and state sectors has been provided for power in the Ninth Plan period (Planning Commission 1999a). This constitutes 14.25% of the total plan, a decline from the 18.4% (Table 34) allocated in the Eighth Plan.

Private sector participation

Decline in the budgetary allocation from the state and central sectors gives rise to the need for private sector investment in the power sector. The shortfall in private sector investments, however, has been due to the emergence of a number of constraints such as (1) unwillingness of lenders to finance large independent projects, (2) high financial risk involved in selling power to a monopoly buyer like the SEBs, and (3) delay in obtaining various statutory clearances.

The extent of private sector investment in the power sector will largely depend upon improvement in the financial conditions of the SEBs through reforms and restructuring. In addition, the ability of independent power producers to enter into reliable fuel-supply agreements and transport arrangements will determine the progress of private investments. The

Power Finance Corporation has provided a major boost to private sector participation by sanctioning loans to the tune of 25 400 million rupees, of which 2560 million rupees has already been disbursed. So far, private projects with a total installed capacity of 5000 MW have been commissioned (Table III). The details of commissioned projects are provided in Table 15.

Table III Status of PPP (private power projects) in July 1999

Description	*Number*	*Capacity (MW)*
Projects with techno-economic clearance from the CEA (Central Electricity Authority)	48	23066
Projects with in-principle clearance from the CEA	25	14309
PPPs commissioned in the past five years	21	5000
PPPs under construction	21	5684
PPPs with finances tied up with IFIs (Indian financial institutions)	57	17062
PPP seeking tie-up with IFIs	50	16183
PPPs awarded through memorandum of understanding / letter of intent	72	38910
PPPs awarded through the competitive bidding route	26	16621

Source MoP (1999)

The planned capacity addition in the private sector during the Ninth Plan period is 17 588 MW. Some of the measures taken by the government to facilitate private sector investment are as follows.

- The government recently reviewed the policy on automatic approval of foreign equity for generation and T&D and has revised the limit from 74% to 100% of equity participation provided the project cost does not exceed 15 000 million rupees. The projects that would qualify for such automatic approval are hydroelectric power plants, coal- and lignite-based thermal power plants, and oil- and gas-based thermal power plants.
- For speedy environmental clearance, the Ministry of Environment and Forests has agreed to delegate powers regarding environmental clearances to the states for cogeneration projects and captive plants up to 250 MW, coal-based plants using fluidized technology up to 500 MW, power stations on conventional technology up to 250 MW, gas/naphtha-based stations up to 500 MW.
- Fuel linkages have been provided for capacity addition based on liquid fuels.
- The limit in respect of different categories of power schemes beyond which the concurrence of the CEA (Central Electricity Authority) would be required has been enhanced in November 1998.
- In view of the large amount of funds required and the limited budgetary support, the ceiling of 15% on lending by the Indian financial institutions to any one sector has been removed.
- The policy announced in 1991 envisaged that not more than 40% of the total outlay for the private sector units may be raised from Indian public financial institutions. The government recently removed the ceiling for the extent of domestic debt, subject to the need for maximizing financing from external sources and the adoption of a norm by Indian public financial institutions whereby a higher domestic debt component would be allowed for projects based on indigenous equipment.
- The SEBs have been restructured in several states.
- Regulatory bodies have been established.

Private sector investment in transmission is proposed to be limited to the construction and maintenance of transmission lines on BOOT (build–own–operate–transfer) basis under the supervision and control of the Powergrid Corporation of India Limited. The Powergrid Corporation of India Limited has been notified as the CTU (central transmission undertaking), and the transmission companies at the state level as the STUs (state transmission undertakings). The functions of the CTU/STU involve identification of the transmission lines, issue of specifications, and selection of the private party. On selection of the private party, the CTU/STU would recommend it to the CERC/SERC (Central Electricity Regulatory Commission/State Electricity Regulatory Commission) for the issuance of a transmission license. The proposed guidelines for private sector participation in power transmission are as follows.

- Private sector can enter power transmission sector through two routes: 100% equity or joint venture with the PGCIL.
- In the case of joint venture route, the PGCIL will hold 26% stake and the remaining 74% will lie with the private partner or a consortium.
- The PGCIL will identify projects to be established at national and regional levels as well as selection of private investors and recommen-

dation to the CERC (Central Electricity Regulatory Commission) for issuance of licences.

- The licences will be issued for a period of 30 years within which the private firm will establish transmission lines on build-own- maintain-transfer basis.
- The PGCIL will take the line on rental basis and charges will not be unit-linked. In the case of joint venture, the tariff will be based on cost-plus basis.
- Meramundali–Jeypore, Madurai–Edamon–Thiruvananthapuram, Purnea–Muzaffar-pur, and Muzaffarpur–Gorakhpur transmission links will be given as test cases to the private sector.

Reforms in the power sector

Due to increased industrialization and commercialization, the increase in demand for electricity outpaces capacity addition leading to a demand–supply gap. Also, it has been recognized that future expansion in generation and T&D cannot be realized through public sector resources alone and that private sector participation needs to be encouraged.

According to the Electricity Supply Act of 1948, the SEBs are required to earn a minimum RoR (rate of return) of three per cent on their net fixed assets in service after providing for depreciation and interest charges. However, most SEBs do not comply with this stipulation and there was only one SEB (Maharashtra) with a positive RoR (with subsidy) in 1998/99 (Planning Commission 1999b). The main reasons for the negative performance are the low tariffs and operating inefficiencies in SEBs. As seen in Figure 3, the average RoR (with subsidy) for the SEBs was as low as –11.7% in 1997/98 and it further plunged to –12.8% in 1998/99 (Planning Commission 1999b).

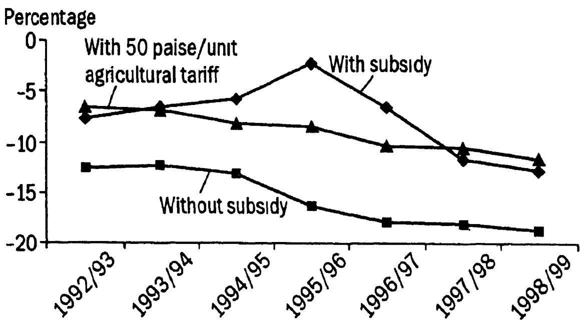

Figure 3 Rate of return on capital with subsidy
Source Planning Commission (1999b)

The future development of the power sector primarily depends on two factors (1) financial viability of the SEBs and (2) their operating efficiency. The SEBs need to be restructured to restore efficiency of operation within a definite timeframe. In addition, the changing scenario in the power sector requires further delegation of powers and simplification of procedures (MoP 1997). The Electricity Regulatory Commission Act, 1998, provides the legal basis for setting up a commission at the central level with separate commissions at the state level. The CERC was formulated under the provisions of this Act on 24 July 1998. The functions of the CERC are listed below (GoI 1998).

1. Regulate the tariff of generating companies owned or controlled by the central government
2. Regulate the tariff of generating companies other than those controlled by the central government, if such generating companies enter into, or otherwise have a composite scheme for, generation and sale of electricity in more than one state
3. Regulate the interstate transmission of energy including tariff of transmission lines
4. Promote competition, efficiency, and economy in the activities of the electricity industry
5. Aid and advise the government in the formulation of a tariff policy which shall be fair to the consumers and facilitate mobilization of resources
6. Associate with the environmental regulatory agencies to develop appropriate policies and procedures for environmental regulation
7. Frame guidelines in matters related to electricity tariff
8. Arbitrate or adjudicate upon disputes involving generating companies or transmission utilities indicated in (1) and (3)
9. Aid and advise the central government on any other matter referred to commission by the government

Section 17(1) of the Electricity Regulatory Commission Act empowers the state government to establish an SERC. The functions of an SERC are given below (GoI 1998).

- Determine the tariff for electricity, wholesale, bulk, grid or retail
- Determine the tariff payable for use of the transmission facilities
- Regulate power purchase and procurement process of transmission utilities and distribution utilities

- Promote competition efficiency and economy in the activities of the electricity industry

The Electricity Supply Amendment Act, 1998, provides for the constitution of a regional electricity board constituted by the central government for a specified region for facilitating the integrated operation of the power system in that region.

Restructuring state electricity boards

The objectives of the power sector reforms are as follows.

- Promote the development of the power sector by ensuring generation and supply at an economic cost
- Provide reliable and high-quality service to the consumer
- Ensure the financial viability of the SEBs, thereby attracting private sector investments

Some of the states that have restructured their SEBs include Orissa, Haryana, Andhra Pradesh, and Rajasthan. Restructuring has also been initiated in Uttar Pradesh, Madhya Pradesh, Gujarat, and Tamil Nadu.

Orissa

Orissa is the first state to have undertaken restructuring of its SEB through the enactment of the Orissa Reform Act, 1995. The World Bank has sanctioned a loan of 350 million dollars. The erstwhile Orissa SEB, which operated as a vertically-integrated utility, has been unbundled into separate corporations for generation, transmission, and distribution. The generation business has been handed over to Orissa Hydro Power Corporation while the Grid Corporation of Orissa Ltd is responsible for transmission. The distribution business has been divided into four zones – central, western, southern, and northern. The process of privatizing the distribution sector for three of the zones is already complete with the BSES (Bombay Suburban Electric Supply Company) having taken over the operations in the western, southern, and north-eastern zones while talks are at an advanced stage for the central zone.

Haryana

The Haryana SEB was converted into two separate entities on 14 August 1998: the Haryana Power Generation Corporation for generation and the Haryana Vidyut Prasaran Nigam Limited for transmission. As regards distribution, the state has been divided into two zones, namely, north and south. The Uttar Vidyut Vitaran Nigam Limited manages the north zone, while the south zone is managed by the Dakshin Vidyut Vitaran Limited.

Andhra Pradesh

The Andhra Pradesh SEB is to be divided into three entities on the lines of the Orissa model. Distribution in the state will be divided into five zones. Fifty-one per cent of the stake in distribution will be offered to the private sector. The state has received presidential assent for the Electricity Reform Bill, 1998, which has led to the formulation of the SERC. Under the provisions of the Andhra Pradesh Electricity Reforms Act, two corporations, namely the Transmission Corporation of Andhra Pradesh Limited and the Andhra Pradesh Power Generation Limited have been formed in place of the Andhra Pradesh SEB.

Rajasthan

Rajasthan was one of the first states to propose a model for privatizing power distribution by offering a majority stake to the private sector. Despite this, the actual process of privatization has been stalled due to various reasons.

Tariff reform

The tariff varies for different consumer categories. The major consumer categories are domestic, agricultural, commercial, industrial, and railway traction. The tariff for the first two categories is less than the average cost of supply while that for the last three categories is more than the average cost of supply (Tables 23 and 24).

The average tariff for sale of electricity by the SEBs increased from 105.4 paise/kWh in 1992/93 to 197.9 paise/kWh in 1998/99 (Table 25). However, large variations within states and across categories exist in the average tariff (Table 30).

The recovery of costs through tariffs is necessary for the financial health of the SEBs. The sales revenue as a percentage of the cost incurred decreased marginally to 78.8% in 1998/99 (Figure 4). The sales revenue to cost ratio is particularly low in Jammu and Kashmir, Assam, and Bihar and below average in a number of other states (Table 36).

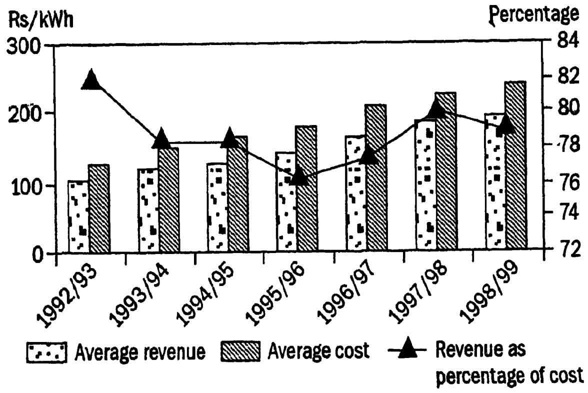

Figure 4 Recovery of cost through tariff
Source Planning Commission (1999b)

Effective subsidy and cross-subsidization

Effective subsidy is defined as the difference between the cost of supply and revenue realization. This figure has increased from 93 700 million rupees in 1992/93 to 222 160 million rupees in 1997/98 and is estimated at 262 780 million rupees in 1998/99. A minimum agricultural tariff of 50 paise/kWh has been introduced in Haryana, Himachal Pradesh, Orissa, Uttar Pradesh, and Meghalaya. However, a substantial gap exists between the subsidy provided to the agricultural and domestic sectors and the total inflows on account of the compensation provided by the state governments and cross-subsidy from the industrial and commercial sectors (Tables 27 and 28). Some state governments partly compensate SEBs for the subsidy provided to the agricultural and domestic sectors. If the state governments do not provide compensation, a part of the subsidy is recovered by the SEBs through cross-subsidization of tariffs for the users in the industrial and commercial sectors.

The cross-subsidy as a percentage of the subsidy was 41.7% in 1992/93 and it increased to about 51% in 1997/98; however, it declined again to 41.5% in 1998/99 (Planning Commission 1999b). The level of cross-subsidization of the industrial and commercial sectors has to be limited as it can affect the competitiveness of these sectors and can also encourage them to set up their own captive generation.

Under Section 59 of the Electricity Supply Act, 1948, the SEBs are required to ensure a minimum overall RoR of three per cent to each utility. Even though cross-subsidization between categories of customers can be permitted by the SEBs, the CERC has recommended that no sector should pay less than 50% of the average cost of supply. Furthermore, tariffs for the agricultural sector should be fixed at not less than 50 paise/kWh (as has been done in some states) and should be raised to 50% of the generation costs subsequently.

Considering the requirement for better utilization of the existing capacity and to meet the peak load demand through commercial signals, the government recently decided to implement plant availability and frequency-linked tariff in generation for the central sector utilities. The move is expected to achieve the following objectives.

- Rational recovery of fixed costs from beneficiaries
- Provide a fiscal mechanism to encourage high availability of plants to meet peak demand
- Encouragement of most economic generation
- Rationalization of the contractual demand between the SEBs and central sector generators.
- Fiscal disincentives for overdrawl during low-frequency conditions and underdrawl during high-frequency conditions

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Table 1

Power scenario in India

State/union territory	Surplus (+)/deficit (–)(%) energy 1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	At the end of the Eighth Five-Year Plan (1996/97) Peak load (MW)	Peak surplus/deficit (MW)	Requirement (million kWh)	Surplus/deficit (MW)
State												
Andhra Pradesh	–7.90	–6.70	–6.90	–4.50	–8.00	–20.20	–22.10	–14.40	5940	1400	40240	–3881
Assam	0	0	–15.80	–11.40	–8.40	–10.80	–10.20	–8.70	511	0	3005	–307
Bihar	–28.70	–29.70	–38.20	–35.40	–33.10	–30.10	–27.50	–19.90	1850	895	9625	–2644
Delhi	–0.70	–1.00	–0.60	–1.50	–1.10	–1.00	–2.60	–1.90	2230	157	14060	–366
Gujarat	–4.10	–4.30	–3.00	–4.50	–4.10	–5.90	–8.10	–5.30	6100	949	38225	–3114
Haryana	–2.90	–2.00	–2.30	–9.40	–4.80	–2.30	–5.90	–1.60	2170	344	13895	–817
Himachal Pradesh	–1.10	–0.70	0	0	0	–0.10	–0.90	–0.10	525	0	2325	–22
Jammu and Kashmir	–10.80	–10.80	–19.50	–19.70	–18.50	–24.50	–18.00	–2.70	900	154	4833	–872
Karnataka	–22.90	–23.60	–25.90	–21.90	–17.20	–20.70	–27.10	–20.30	4220	1201	24940	–6768
Kerala	–0.50	–3.30	–3.70	–1.90	–0.80	–14.30	–22.70	–19.00	2040	489	11415	–2595
Madhya Pradesh	–2.50	–5.60	–7.90	–4.80	–7.30	–8.80	–12.00	–6.70	6200	1805	33045	–3949
Maharashtra	–3.90	–4.50	–5.90	–3.10	–2.00	–2.30	–5.60	–2.90	9400	815	60181	–3357
Meghalaya	0.00	0.00	–2.00	0.00	0.00	–3.00	0.00	3.10	102	0	412	0
Orissa	–22.00	–7.00	–12.80	–10.50	–7.40	–4.70	–3.00	–1.80	1960	271	10605	–323
Punjab	–1.10	–6.20	–3.60	–3.20	–3.90	–1.90	–1.60	–0.80	4020	325	21770	–356
Rajasthan	–2.10	–1.40	–1.60	–6.10	–5.40	–3.20	–7.40	–1.80	3085	174	20080	–1485
Tamil Nadu	–6.40	–4.80	–1.80	–3.90	–2.80	–10.90	–13.80	–14.10	5800	923	36080	–4962
Uttar Pradesh	–10.60	–10.30	–10.20	–9.70	–12.20	–11.40	–13.90	–12.30	6680	1334	41365	–5765
West Bengal	–9.20	–9.00	–5.40	–5.00	–6.10	–4.80	–2.90	–0.70	2800	312	15475	–449
Union territory												
Arunachal Pradesh	0	0	–31.00	–31.70	–24.80	–35.50	–48.50	–20.10	51	11	163	–79
Goa	0	0	0	–0.30	0	0	0	0	198	0	1273	0
Manipur	0	0	–11.20	–4.50	–14.90	–15.10	–10.70	–20.10	78	17	417	–45
Mizoram	0	0	–16.20	–4.60	–11.90	–16.70	–19.20	–20.80	49	—	139	–36
Nagaland	0	0	–15.40	–5.70	–14.60	–15.50	–16.10	–25.40	42	3	187	–30
Pondicherry	–18.00	–28.10	0	0	0	0	0	0	0	0	0	0
Sikkim	0	0	0	0	0	0	0	0	0	0	0	0
Tripura	0	0	–17.90	–10.10	–12.60	–21.00	–23.80	–14.10	88	20	483	–115
Overall average	**–7.90**	**–7.80**	**–8.30**	**–7.30**	**–7.10**	**–9.80**	**11.50**	**–8.10**	—	—	—	—

DESU - Delhi Electricity Supply Undertaking

Source

Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 77 New Delhi Planning Commission, Power and Energy Division, Government of India

Table 2

Distribution of power sector outlay for 1995/96 and total outlay: 1995/96 to 1997/98

State electricity board/electricity department	*Generation (%)* *(1995/96)*	*Renovation and modernization (%)* *(1995/96)*	*Transmission and distribution (%)* *(1995/96)*	*Miscellaneous (%)* *(1995/96)*	*Rural electrification (%)* *(1995/96)*	*Total outlay (million rupees)* *(1995/96)*	*Total outlay (million rupees)* *(1996/97)*	*Total outlay (rupees million)* *(1997/98)*
State electricity board								
Andhra Pradesh	71.7	0.9	22.9	0.2	4.3	6987.7	6193	9176
Assam	13.3	19.7	33.5	1.0	32.5	2029.5	1657	1620
Bihar	47.7	23.0	25.2	0.3	3.8	4132.6	1089	1033
Delhi	16.1	1.5	81.4	0.8	0.2	4377.5	4164	2980
Gujarat	33.7	2.4	55.7	0.2	8.0	5032.3	5032	6208
Haryana	31.6	7.1	48.4	0	12.9	2610.0	2613	2874
Himachal Pradesh	62.6	0.6	25.2	1.5	10.1	1387.9	1473	1649
Jammu and Kashmir	49.6	1.5	40.8	1.2	6.9	3065.7	3749	3938
Karnataka	52.8	2.3	34.1	2.5	8.3	6800.0	5810	6081
Kerala	53.1	1.6	39.8	1.1	4.4	4500.0	5491	6270
Madhya Pradesh	50.6	3.4	38.0	0.3	7.7	8006.3	7027	6383
Maharashtra	50.0	1.4	36.7	1.1	10.8	10827.4	12518	14574
Meghalaya	9.5	0	60.6	2.6	27.3	356.5	357	916
Orissa	18.3	2.3	48.5	25.2	5.7	2615.7	4020	6046
Punjab	80.1	1.2	14.3	0.7	3.7	6993.2	6826	7840
Rajasthan	50.1	1.1	34.4	0.3	14.1	8113.2	7300	7022
Tamil Nadu	61.9	2.8	31.3	0.8	3.2	7660.9	7000	8704
Uttar Pradesh	25.3	7.2	56.6	2.9	8.1	18798.1	12440	18032
West Bengal	75.3	1.4	16.3	0.8	6.2	6142.5	12153	12539
Electricity department								
Arunachal Pradesh	45.5	0	38.3	1.9	14.3	770.0	845	961
Goa	0.2	0	93.8	5.4	0.6	176.0	198	199
Manipur	1.1	0.7	67.9	1.2	29.1	445.0	422	430
Mizoram	54.2	5.9	31.5	3.4	5.0	296.0	437	356
Nagaland	77.8	0	22.2	0	0	214.1	214	212
Pondicherry	40.2	0	59.8	0	0	400.1	434	452
Sikkim	41.4	5.8	40.5	6.5	5.8	258.8	309	309
Tripura	45.3	8.5	30.9	2.8	12.5	480.0	332	287
Total						113477	110103	127091

Source
Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. pp. 16, 23.
New Delhi. Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (plan statistics)]

Table 3

Installed capacity (MW) 1995/96 to 1997/98

State/sector	1995/96					1996/97							1997/98						
	Hydel	%	Thermal	%	Total	Hydel	%	Thermal	%	Wind	%	Total	Hydel	%	Thermal	%	Wind	%	Total
State																			
Andhra Pradesh	2656.9	51.0	2553.5	49.0	5210.4	2656.9	48.2	2801.5	50.8	54.3	1.0	5512.7	2656.9	46.1	3051.5	52.9	55.8	1.0	5764.2
Assam	2.0	0.3	595.2	99.7	597.2	2.0	0.3	595.2	99.7	0	0	597.2	2.0	0.3	614.7	99.7	0	0	616.7
Bihar	164.9	9.3	1603.5	90.7	1768.4	169.9	8.6	1813.5	91.4	0	0	1983.4	174.9	8.8	1813.5	91.2	0	0	1988.4
Delhi	0	0	653.6	100.0	653.6	0	0	653.6	100.0	0	0	653.6	0	0	653.6	100.0	0	0	653.6
Gujarat	487.0	10.9	3960.8	89.1	4447.8	487.0	10.6	3944.3	86.2	146.8	3.20	4578.1	487.0	10.0	4229.3	86.6	166.9	3.4	4883.2
Haryana	883.9	49.6	896.4	50.4	1780.3	48.0	5.1	896.4	94.9	0	0	944.4	48.0	5.1	896.4	94.9	0	0	944.4
Himachal Pradesh	288.9	100.0	0.1	0	289.0	299.4	100.0	0.1	0	0	0	299.5	299.4	100.0	0.1	0.0	0	0	299.5
Jammu and Kashmir	184.1	49.8	181.8	49.7	365.9	184.1	49.8	181.8	49.7	0	0	365.9	184.1	49.8	181.8	49.7	0	0	365.9
Karnataka	2391.6	71.1	969.9	28.9	3361.5	2391.6	71.0	969.9	28.8	5.9	0.2	3367.4	2447.6	71.3	969.9	28.2	17.0	0.5	3434.5
Kerala	1479.5	100.0	0.0	0	1479.5	1551.5	99.9	0	0	2.0	0.1	1553.5	1671.5	95.3	80.0	4.6	2.0	0.1	1753.5
Madhya Pradesh	846.1	21.9	3017.5	78.1	3863.6	846.1	21.8	3017.5	77.9	9.6	0.2	3873.2	846.1	21.8	3017.5	77.9	12.3	0.3	3875.9
Maharashtra	1354.2	17.4	6417.0	82.6	7771.2	1359.2	17.5	6417.0	82.5	5.4	0.1	7781.6	1367.2	16.5	6917.0	83.4	5.6	0.1	8289.8
Meghalaya	186.7	96.4	7.1	3.6	193.8	186.7	98.9	2.1	1.1	0	0	188.8	186.7	98.9	2.1	1.1	0	0	188.8
Orissa	1271.9	64.1	420.0	24.8	1691.9	1271.9	64.5	420.0	24.8	1.1	0.1	1693.0	1271.9	64.5	420.0	24.8	1.1	0.1	1693.0
Punjab	1798.9	51.3	1710.0	48.7	3508.9	545.1	24.2	1710.0	75.8	0	0	2255.1	545.1	22.1	1920.0	77.9	0	0	2465.1
Rajasthan	971.1	44.8	1013.5	51.1	1984.6	356.3	26.0	1013.5	74.0	0	0	1369.8	356.3	26.0	1013.5	74.0	0	0	1369.8
Tamil Nadu	1947.7	38.4	3119.4	61.6	5067.1	1947.7	34.0	3100.0	54.2	674.9	11.8	5722.6	1955.7	33.9	3100.0	53.8	707.3	12.3	5763.0
Uttar Pradesh	1504.8	24.8	4564.0	75.2	6068.8	1504.8	24.8	4554.0	75.2	0	0	6058.8	1504.8	24.4	4664.0	75.6	0	0	6168.8
West Bengal	96.5	3.4	2757.4	96.6	2853.9	96.5	3.4	2777.5	96.6	0	0	2874.0	126.5	4.4	2777.5	95.6	0	0	2904.0
Arunachal Pradesh	23.6	59.7	15.9	40.3	39.5	23.6	59.7	15.9	40.3	0	0	39.5	29.6	65.0	15.9	35.0	0	0	45.5
Chandigarh	0	0	2.0	0	2.0	0	0	2.0	100.0	0	0	2.0	0	0	2.0	100.0	0	0	2.0
Goa	0.1	0	0.1	0	0.2	0.1	31.3	0	0	0.1	68.8	0.2	0.1	31.3	0	0	0.1	68.8	0.2
Manipur	2.6	21.6	9.4	78.4	12.0	2.6	21.7	9.4	78.3	0	0	12.0	2.6	21.7	9.4	78.3	0	0	12.0
Mizoram	5.3	20.7	20.4	79.3	25.7	5.3	20.7	20.4	79.3	0	0	25.7	5.3	20.7	20.4	79.3	0	0	25.7
Nagaland	3.5	63.6	2.0	36.4	5.5	3.5	63.6	2.0	36.4	0	0	5.5	3.5	63.6	2.0	36.4	0	0	5.5
Pondicherry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sikkim	32.9	92.4	2.7	7.6	35.6	32.90	92.40	2.70	7.60	0	0	35.6	32.9	92.4	2.7	7.6	0	0	35.6
Tripura	16.0	23.1	53.4	76.9	69.4	16.00	20.70	61.40	79.30	0	0	77.4	16.0	18.7	69.4	81.3	0	0	85.4
Bhakra Beas Management Board	2704.5	100.0	0	0	2704.5	2704.5	100.0	0	0	0	0	2704.5	2704.5	100.0	0	0	0	0	2704.5
Central sector																			
Badarpur Thermal Power Station	0	0	720.0	100.0	720.0	0	0	720.0	100.0	0	0	720.0	0	0	720.0	100.0	0	0	720.0
Department of Atomic Energy	0	0	2225.0	100.0	2225.0	0	0	2225.0	100.0	0	0	2225.0	0	0	2225.0	100.0	0	0	2225.0
Damodhar Valley Corporation	144.0	5.9	2307.5	94.1	2451.5	144.0	5.4	2517.5	94.6	0	0	2661.5	144.0	5.0	2727.5	95.0	0	0	2871.5
North-Eastern Electric Power Corporation Ltd	150.0	47.2	167.5	52.8	317.5	250.0	55.4	201.0	44.6	0	0	451.0	250.0	43.6	324.0	56.4	0	0	574.0
Neyveli Lignite Corporation	0	0	2070.0	100.0	2070.0	0	0	2070.0	100.0	0	0	2070.0	0	0	2070.0	100.0	0	0	2070.0
National Hydroelectric Power Corporation Ltd	1635.0	100.0	0	0	1635.0	2115.0	100.0	0	0	0	0	2115.0	2115.0	100.0	0	0	0	0	2115.0
National Thermal Power Corporation	0	0	16804.0	100.0	16804.0	0	0	16804.0	100.0	0	0	16804.0	0	0	16804.0	100.0	0	0	16804.0
Private sector																			
Ahmedabad Electric Company Ltd	0	0	550.6	100.0	550.6	0	0	549.0	100.0	0	0	549.0	0	0	549.0	100.0	0	0	549.0
Andhra Pradesh Gas Power Corporation Ltd	0	0	0.2	100.0	0.2	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0
Calcutta Electric Supply Company	0	0	695.0	100.0	695.0	0	0	695.0	100.0	0	0	695.0	0	0	945.0	100.0	0	0	945.0
Tata Electric Company (Maharashra)	426.0	24.3	1330.0	75.7	1756.0	426.0	24.3	1330.0	75.7	0	0	1756.0	426.0	24.3	1330.0	75.7	0	0	1756.0
Bombay Suburban Electric Supply	0	0	500.0	0	500.0	0	0	500.0	0	0	0	500.0	0	0	500.0	0.0	0	0	500.0
Others	0	0	35.3	100.0	35.3	0.1	0.2	35.3	100.0	0	0	35.3	0.1	0.2	35.3	100.0	0	0	35.3
Grand total	20985.0	25.2	62307.9	74.8	83292.9	21658.1	25.2	63237.3	73.7	900.0	1.0	85795.4	21891.1	24.6	66230.8	74.3	968.1	1.1	89090.0

Note

Nuclear included in thermal

Source

Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments pp 35–42 New Delhi Power and Energy Division, Planning Commission, Government of India

Table 4

Installed capacity of utilities by region and state (MW): 1 January 1999

State/union territory/ central sector	*Hydro*	*Steam*	*Diesel and wind*	*Gas*	*Nuclear*
Northern region					
Haryana	883.9	892.5	3.9	0	0
Himachal Pradesh	299.4	0	0.1	0	0
Jammu and Kashmir	184.1	0	6.8	175.0	0
Punjab	1798.9	2130.0	0	0.0	0
Rajasthan	971.1	1225.0	0	38.5	0
Uttar Pradesh	1507.8	4664.0	0	0	0
Chandigarh	0	0	2.0	0	0
Delhi	0	371.6	0	282.0	0
Central sector	2010.0	5190.0	0	1882.0	895.0
Sub-total	**7655.1**	**14473.1**	**12.8**	**2377.5**	**895.0**
Western region					
Gujarat	547.0	4674.0	184.4	1634.0	0
Madhya Pradesh	846.1	3017.5	12.3	0	0
Maharashtra	1801.2	7655.0	5.6	1092.0	0
Goa	0.1	0	0.1	0	0
Dadra and Nagar Haveli	0	0	0	0	0
Daman and Diu	0	0	0	0	0
Central sector	0	3360.0	0	1292.0	860.0
Sub-total	**3194.4**	**18706.5**	**202.4**	**4018.0**	**860.0**
Southern region					
Andhra Pradesh	2656.9	2952.5	55.8	542.0	0
Karnataka	2555.6	1050.0	146.9	130.0	0
Kerala	1699.5	0	102.0	0	0
Tamil Nadu	1955.7	2970.0	807.3	130.0	0
Lakshadweep	0	0	6.92	0	0
Pondicherry	0	0	0	22.9	0
Central sector	0	4170.0	0	115.3	470.0
Sub-total	**8867.7**	**11142.5**	**1112.0**	**940.6**	**470.0**
Eastern region					
Bihar	174.9	1813.5	0	0	0
Orissa	1271.9	420.0	1.1	0	0
West Bengal	141.5	3626.4	22.5	100.0	0
Andaman and Nicobar Islands	0	0	28.3	0	0
Sikkim	32.9	0	2.7	0	0
Central sector	144.0	6547.5	0	90.0	0
Sub-total	**1765.2**	**12407.4**	**26.3**	**190.0**	**0**
North-eastern region					
Assam	2.0	330.0	20.7	269.0	0
Manipur	2.6	0	9.4	0	0
Meghalaya	186.7	0	2.1	0	0
Nagaland	3.5	0	2.0	0	0
Tripura	16.0	0	4.9	64.5	0
Arunachal Pradesh	29.6	0	15.9	0	0
Mizoram	5.3	0	20.4	0	0
Central sector	355.0	0	0	375.0	0
Sub-total	**600.7**	**330.0**	**75.2**	**708.5**	**0**
All-India	**22083.1**	**57059.5**	**1464.0**	**8234.6**	**2225.0**

Source

MoP. 1999. Annual Report 1998/99. New Delhi: Central Electricity Authority, Ministry of Power

For more details, please see TEDDY ONLINE+ [Section: Power (generation–utility)]

Table 5

Annual plant load factor (%) of thermal stations 1990/91 to 1997/98

Agency	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
State electricity board								
Northern region	**55.2**	**58.0**	**62.0**	**64.0**	**59.1**	**62.0**	**64.7**	**66.7**
Haryana	34.5	45.8	49.9	40.5	44.7	42.9	47.7	49.4
Punjab	52.9	52.8	58.3	63.5	56.7	55.0	65.7	69.1
Rajasthan	42.8	65.7	77.0	81.0	75.6	73.7	75.6	80.5
Uttar Pradesh	52.1	44.3	50.5	50.3	43.9	47.3	49.1	48.8
Western region	**57.7**	**59.6**	**59.7**	**63.4**	**63.8**	**68.1**	**70.2**	**70.3**
Gujarat	57.7	56.9	61.6	60.4	60.5	65.3	64.8	65.6
Maharashtra	58.1	61.3	59.7	64.1	61.2	64.9	68.7	68.3
Madhya Pradesh	52.7	49.2	52.5	56.1	58.2	58.7	62.3	66.0
Southern region	**61.7**	**60.8**	**62.6**	**68.3**	**69.1**	**74.7**	**75.8**	**77.1**
Andhra Pradesh	65.8	62.1	65.0	68.7	70.2	77.4	78.3	82.0
Tamil Nadu	58.3	55.7	65.2	69.0	68.1	76.1	72.3	68.1
Karnataka	76.3	59.1	49.4	66.9	64.9	67.7	70.2	75.2
Eastern region	**36.5**	**37.3**	**39.8**	**44.8**	**43.7**	**42.7**	**42.2**	**43.0**
Bihar	23.9	21.3	25.2	24.4	20.0	17.4	15.3	16.1
Orissa	33.9	30.2	34.5	35.5	29.0	67.0	69.4	65.3
West Bengal	30.9	30.8	31.1	40.5	41.2	34.6	39.2	40.0
North-eastern region	**24.6**	**24.6**	**24.3**	**19.9**	**26.8**	**28.6**	**27.1**	**21.3**
Assam	24.6	24.6	24.3	19.9	26.7	28.6	27.1	21.3
Total	**51.3**	**50.6**	**54.1**	**56.6**	**55.0**	**58.0**	**60.3**	**60.9**
Central sector	**58.1**	**64.5**	**62.7**	**69.8**	**69.2**	**70.9**	**71.0**	**70.4**
National Thermal Power Corporation	60.9	69.2	68.8	76.9	76.2	76.7	76.4	74.4
Neyveli Lignite Corporation	69.8	66.3	56.4	55.5	60.4	67.6	70.3	72.5
Damodhar Valley Corporation	33.3	33.6	32.3	42.3	38.2	37.8	35.6	38.4
Durgapur Power Limited	24.4	17.8	28.7	26.3	26.6	26.5	29.5	25.3
Delhi Vidyut Board	50.7	57.2	54.0	49.0	53.9	51.7	41.7	47.2
West Bengal Power Development Corporation	57.3	61.4	58.1	68.2	60.4	57.6	56.5	52.8
Private sector	**58.4**	**64.5**	**54.1**	**56.6**	**65.9**	**72.3**	**71.2**	**71.1**
Ahmedabad Electric Company Limited	67.1	67.3	62.5	67.0	69.1	69.3	71.4	71.3
Trombay	54.7	53.0	54.3	48.8	60.6	72.8	68.8	63.5
Calcutta Electricity Supply Company	60.8	58.3	67.5	71.3	75.6	78.9	74.9	76.9
All-India	**53.9**	**55.3**	**57.1**	**61.0**	**60.0**	**63.0**	**64.4**	**64.7**

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments, 1997 p 47

New Delhi Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section Power (generation–thermal)]

Table 6

Annual gross generation in utilities (GWh): 1975/76 to 1997/98

Type	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Hydel	33301	46542	51021	71641	72757	69869	70463	82712	72579	68609	74388
Thermal (includes diesel, wind, gas, and steam)	43303	61301	114347	186546	208747	224766	248189	262130	299316	316869	336033
Nuclear	2626	3001	4982	6141	5524	6726	5398	5648	7982	9010	9984
Total	**79230**	**110844**	**170350**	**264328**	**287028**	**301361**	**324050**	**350490**	**379877**	**394488**	**420405**

Sources

1 Planning Commission 1996. Annual Plan 1995/96. p. 337. New Delhi. Planning Commission, Government of India. 597 pp.

2 CEA. 1999. Public Electricity Supply, All India Statistics, General Review, 1995/96. pp 59–68. New Delhi: Central Electricity Authority. 214 pp.

3 MoP. 1998. Annual Report 1997/98 New Delhi: Ministry of Power.

4 Planning Commission. 1999. Annual Report on the Working of State Electricity Boards and Electricity Departments, 1997. pp. 51–53. New Delhi· Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (generation–utility)]

Table 7

Captive capacity (MW) and generation (GWh): 1980/81 to 1995/96
(in respect of installed capacity of 1 MW and above)

Year and item	*Steam*	*Diesel*	*Others*	***Total***
1980/81				
Installed capacity	2116.5	868.0	56.9	**3041.4**
Energy generated	7202.7	1054.0	116.9	**8373.6**
PLF (plant load factor) (%)	38.8	13.9	23.5	**25.2**
1985/86				
Installed capacity	2881.6	2378.4	159.1	**5419.1**
Energy generated	10226.8	2350.9	419.6	**12997.3**
PLF (%)	40.5	11.3	30.1	**27.3**
1990/91				
Installed capacity	4991.1	3031.7	478.8	**8501.6**
Energy generated	20005.7	3216.3	1859.8	**25081.8**
PLF (%)	45.8	12.1	44.3	**34.1**
1991/92				
Installed capacity	5377.1	3291.1	500.0	**9168.2**
Energy generated	23409.4	3247.8	1922.8	**28580.0**
PLF (%)	49.7	11.3	43.9	**35.0**
1992/93				
Installed capacity	5540.7	3726.7	637.1	**9904.5**
Energy generated	24679.8	3851.0	3797.0	**32327.8**
PLF (%)	54.2	11.8	68.0	**37.3**
1993/94				
Installed capacity	5793.0	3995.1	786.6	**10574.7**
Energy generated	25407.5	3684.4	3170.7	**32262.6**
PLF (%)	50.1	10.5	46.0	**34.8**
1994/95				
Installed capacity	6010.5	4156.1	846.4	**11013.0**
Energy generated	27387.9	4102.7	3553.3	**35043.9**
PLF (%)	52.0	11.3	47.9	**36.3**
1995/96				
Installed capacity	6305.3	4199.4	1124.3	**11629.0**
Energy generated	28751.7	4334.4	5056.1	**38142.2**
PLF (%)	—	—	—	—

Source

CEA 1999 Public Electricity Supply, All India Statistics, General Review, 1995/96. New Delhi Central Electricity Authority 214 pp

For more details, please see TEDDY ONLINE+ [Section: Power (generation–captive)]

Table 8

Purchase of power by major sources (million kWh): 1992/93 to 1998/99

State electricity board/electricity department	1992/93		1993/94		1994/95		1995/96		1996/97		1997/98		1998/99	
	Central sector	*Others*	*Central sector*	*Others*	*Central sector*	*Others*	*Central sector*	*Others*	*Central sector*	*Others*	*Central sector*	*Others*	*Central sector*	*Others*
State electricity board														
Andhra Pradesh	6748	446.0	7612.0	637.0	8449.0	680.0	7814.0	918.0	7446.0	1055.0	8268.0	2931.0	8515.0	4123.0
Assam	773.0	269.1	807.0	428.0	963.4	127.0	931.9	214.5	1240.9	155.4	1425.0	312.0	1453.0	230.0
Bihar	4398.0	78.6	4926.0	72.0	5915.1	152.7	6746.2	113.5	6707.9	737.8	7061.0	1102.0	7278.0	1621.0
Delhi (DESU)	7426.8	658.1	0	0	9693.2	0	10905.2	72.8	11678.1	0	12481.9	48.2	13731.0	0
Gujarat	4800.0	642.0	6466.0	430.0	6656.0	395.0	8978.0	820.0	9484.0	1772.0	10320.0	3915.0	10320.0	8130.0
Haryana	3713.0	445.0	4760.0	225.0	4561.0	122.0	5929.0	183.0	5947.0	303.0	5357.0	983.0	4980.0	1063.0
Himachal Pradesh	649.0	364.1	808.0	284.0	700.7	751.2	1094.6	583.4	1048.7	784.3	1065.0	949.0	1063.0	995.0
Jammu and Kashmir	1893.2	89.8	2084.6	185.4	2179.0	104.0	2355.5	131.8	2921.6	131.4	3725.0	130.0	4404.0	0.0
Karnataka	3622.0	11480.0	3502.0	12814.0	3395.0	14982.0	4490.0	13960.0	5791.0	11905.0	4900.0	14582.0	4020.0	14333.0
Kerala	1232.5	0	2020.0	0	2247.2	0.0	2638.1	0	3296.4	0	3850.0	0	3747.0	0
Madhya Pradesh	9084.0	469.0	10336.0	0	10500.4	273.8	11680.8	483.2	12408.9	410.2	12815.0	0	12815.0	0
Maharashtra	6500.0	2536.0	6266.0	3379.0	6268.0	3316.0	8705.0	4557.0	8413	4449.0	10452.0	4502.0	9500.0	5911.0
Meghalaya	0	57.4	50.0	4.0	78.5	11.5	55.6	0	78.3	0	90.1	0	181.1	0
Orissa	1253.0	833.0	1337.0	2432.0	1347.0	3013.0	2511.0	3756.0	3104.0	7061.0	3507.0	7450.0	3710.0	8400.0
Punjab	3428.0	63.0	3747.0	280.0	3917.0	163.0	4506.0	466.0	5023.0	23.0	5475.0	350.0	5475.0	350.0
Rajasthan	5617.0	1088.0	6463.0	1049.0	7405.7	867.2	9080.3	905.3	8595.8	940.9	9440.0	264.0	9640.0	560.0
Tamil Nadu	7246.0	11.0	8014.0	44.0	9028.0	10.0	8740.0	10.0	8979.0	688.0	9445.0	816.0	9445.0	950.0
Uttar Pradesh	12785.0	39.0	12322.0	453.0	12580.0	751.0	13357.0	675.0	13726.0	283.0	14295.0	5.0	14790.0	6.0
West Bengal	729.0	4831.0	537.0	5337.0	945.8	5853.1	2284.0	6174.9	2449.2	6271.6	2775.0	5940.0	2770.0	6320.0
Sub-total	**81897.9**	**24400.1**	**82057.6**	**28053.4**	**96830.0**	**31572.5**	**103721.9**	**34024.4**	**118338.8**	**36970.6**	**126747.0**	**44279.2**	**127837.1**	**52992.0**
Electricity department														
Arunachal Pradesh	24.9	0	30.4	0	40.2	0	57.4	0	60.0	0	65.0	0	70.0	0
Goa	817.4	0.1	990.2	0	1006.9	0	1146.8	0	1269.1	0	1350.0	0	1267.9	207.1
Manipur	246.7	5.8	276.0	0.4	238.2	0.1	254.9	0.1	303.7	0.1	319.0	0.1	362.5	0.7
Mizoram	70.1	2.2	90.1	0	96.0	8.4	110.6	15.0	144.2	6.4	130.9	6.8	144.0	42.5
Nagaland	102.8	25.5	136.4	0	125.6	16.0	136.4	19.7	156.1	22.8	159.3	23.3	162.5	23.7
Pondicherry	647.1	178.4	663.4	169.5	780.3	195.8	786.8	195.1	765.0	218.2	833.3	260.6	916.7	286.6
Sikkim	24.4	0	22.9	0	27.1	0	41.6	0	38.4	0	46.3	0	38.0	0
Tripura	49.3	21.8	101.5	2.0	108.6	3.9	127.7	1.1	128.2	0	153.3	0	85.7	0
Sub-total	**1982.7**	**233.8**	**2311.5**	**171.9**	**2422.9**	**224.2**	**2662.2**	**231.0**	**2864.7**	**247.5**	**3057.1**	**290.8**	**3047.3**	**560.6**
Grand total	**83880.6**	**24633.9**	**84368.6**	**28225.3**	**99252.9**	**31796.7**	**106384.1**	**34255.4**	**121203.5**	**37218.1**	**129804.1**	**44570.0**	**130884.4**	**53552.6**

DESU - Delhi Electricity Supply Undertaking

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 58. New Delhi. Power and Energy Division, Government of India

Table 9

Electricity production and consumption in select industries: 1995/96

Industry	Number of factories	Installed capacity (kW) as on 31 March 1996						Energy generated (GWh) 1995/96					
		Hydro	Steam	Diesel	Gas	Wind	Total	Hydro	Steam	Diesel	Gas	Wind	Total
Aluminium (primary)	4	0	1408500	0	0	0	1408500	0	10310.61	0.00	0.00	0.00	10310.61
Aluminium (secondary)	7	0	62000	7928	0	0	69928	0	272.33	2.95	0.00	0.00	275.28
Automobile	44	0	0	164496	40000	0	204496	0	0.00	85.02	134.05	0.00	219.07
Cement (primary)	92	0	298016	533629	0	17350	848995	0	811.21	927.01	0.00	16.17	1754.39
Cement (secondary)	21	0	4000	50057	1250	0	55307	0	0.00	34.12	0.00	0.00	34.12
Chemicals	117	0	382338	306874	65400	18500	773112	0	1239.98	399.54	487.39	11.64	2138.55
Colliery	12	0	104500	11600	0	0	116100	0	319.64	3.69	0.00	0.00	323.33
Electrical engineering	62	0	15000	136656	0	0	151656	0	5.24	77.26	0.00	0.00	82.50
Fertilizer	42	0	611430	94416	229940	0	935786	0	2558.37	205.17	861.71	0.00	3625.25
Food product	46	0	6600	80865	500	2025	89990	0	17.25	30.65	0.32	2.96	51.18
Heavy engineering	38	0	7000	143158	0	0	150158	0	0.00	82.41	0.00	0.00	82.41
Iron and steel (primary)	14	0	1292000	113834	0	0	1405834	0	6624.57	60.32	0.00	0.00	6684.89
Iron and steel (secondary)	62	0	21000	172736	25700	0	219436	0	28.85	117.91	120.93	0.00	267.69
Jute	79	0	16640	209712	0	0	226352	0	59.17	99.20	0.00	0.00	158.37
Light engineering	97	0	4000	252898	0	0	256898	0	3.40	137.25	0.00	0.00	140.65
Mineral oil and petroleum	25	0	309945	113137	322722	0	745804	0	1159.95	69.43	1252.46	0.00	2481.84
Mining and quarrying	11	0	8400	24780	0	0	32580	0	6.34	17.85	0.00	0.00	24.19
Miscellaneous	98	0	2700	208894	145000	63250	419844	0	4.05	165.74	1113.10	228.00	1510.89
Non-ferrous	29	0	118775	252138	23900	0	394813	0	625.32	504.58	46.41	0.00	1176.31
Paper	60	0	460475	71556	0	0	532031	0	1785.75	62.02	0.00	0.00	1847.77
Plastic	4	0	5350	6200	12500	0	24050	0	26.33	0.12	37.88	0.00	64.33
Rubber	22	0	20600	128137	0	0	148737	0	41.90	104.96	0.00	0.00	146.86
Sugar	320	0	877255	106794	500	4500	989049	0	1965.68	137.56	0.00	20.00	2123.24
Textile	451	3500	268771	1009350	88000	59750	1429371	17.39	885.75	1009.59	522.00	183.77	2618.50
Total	**1757**	**3500**	**6305295**	**4199397**	**955412**	**165375**	**11628979**	**17.39**	**28751.69**	**4334.35**	**4576.25**	**462.54**	**38142.22**

Source
CEA. 1995 Public Electricity Supply, All India Statistics, General Review, 1995/96 pp. 95–98. New Delhi: Central Electricity Authority. 214 pp

For more details, please see TEDDY ONLINE+ [Section: Power (generation–captive)]

Table 9 A

Electricity production and consumption (GWh) in selected industries: 1995/96

Industry	*Energy used in station auxiliaries*	*Net energy generation*	*Energy sold to utilities*	*Energy used in the industry out of self generation*	*Energy purchased from utilities*	*Energy consumed in the industry*
Aluminium (primary)	1065.18	9245.43	1331.43	8183.00	329.73	8512.73
Aluminium (secondary)	85.27	190.01	0.00	190.01	72.92	262.93
Automobiles	3.35	215.72	28.38	187.34	604.11	791.45
Cement (primary)	131.55	1622.84	0.00	1622.84	4822.65	6445.49
Cement (secondary)	1.14	32.98	0.00	32.98	437.83	470.81
Chemical	163.45	1975.10	62.00	1913.10	3062.22	4975.32
Colliery	46.07	277.26	108.84	168.42	808.02	976.44
Electrical engineering	2.10	80.40	0.00	80.40	620.64	701.04
Fertilizer	354.67	3270.58	9.31	3261.27	2685.14	5946.41
Food product	0.83	50.35	0.00	50.35	239.05	289.40
Heavy engineering	5.09	77.32	0.00	77.32	680.92	758.24
Iron and steel (primary)	916.05	5768.84	106.84	5662.00	4573.51	10235.51
Iron and steel (secondary)	6.92	260.77	0.00	260.77	920.05	1180.82
Jute	10.18	148.19	0.00	148.19	707.25	855.44
Light engineering	3.64	137.01	0.00	137.01	1012.52	1149.53
Mineral oil and petroleum	147.20	2334.64	45.07	2289.57	356.77	2646.34
Mining and quarrying	0.87	23.32	0.00	23.32	124.30	147.62
Miscellaneous	44.67	1466.22	504.39	961.83	–117.64	844.19
Non-ferrous	60.24	1116.07	85.00	1031.07	2215.89	3246.96
Paper	176.18	1671.59	0.00	1671.59	1500.38	3171.97
Plastic	3.48	60.85	0.00	60.85	120.84	181.69
Rubber	7.72	139.14	0.00	139.14	664.90	804.04
Sugar	128.91	1994.33	19.90	1974.43	431.28	2405.71
Textile	127.14	2491.36	180.45	2310.91	7067.76	9378.67
Total	**3491.90**	**34650.32**	**2212.61**	**32437.71**	**33941.04**	**66378.75**

Source

CEA. 1995. Public Electricity Supply, All India Statistics, General Review, 1995/96. pp. 95–98. New Delhi: Central Electricity Authority. 214 pp.

For more details, please see TEDDY ONLINE+ [Section: Power (generation–captive)]

Table 10

Coal consumption (kg/kWh of generation) by coal-based thermal units: 1992/93 to 1998/99

State electricity board/agency	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	0.84	0.86	0.83	0.83	0.82	0.81	0.80
Assam	0	0	0	0.67	0.67	0.67	0.67
Bihar	0.90	0.91	0.95	0.97	1.03	0.83	0.99
Delhi Vidyut Board	0.77	0	0	0.83	0.84	0.88	0.83
Gujarat	0.63	0.66	0.67	0.63	0.69	0.74	0.08
Haryana	0.73	0.80	0.79	0.75	0.81	0.85	0.85
Himachal Pradesh	0	0	0	0	0	0	0
Jammu and Kashmir	0	0	0	0	0	0	0
Karnataka	0	0	0	0	0	0	0
Karnataka Power Corporation	0.74	0.74	0.73	0.78	0.81	0.75	0.75
Kerala	0	0	0	0	0	0	0
Madhya Pradesh	0.83	0.80	0.82	0.81	0.80	0.80	0.80
Maharashtra	0.80	0.80	0.80	0.80	0.79	0.80	0.80
Meghalaya	0	0	0	0	0	0	0
Orissa	1.01	0.95	0.88	0	0	0	0
Punjab	0.68	0.74	0.74	0.71	0.70	0.70	0.70
Rajasthan	0.69	0.70	0.74	0.66	0.65	0.70	0.71
Tamil Nadu	0.75	0.75	0.75	0.70	0.70	0.76	0.78
Uttar Pradesh	0.82	0.80	0.80	0.78	0.78	0.79	0.80
West Bengal	0.59	0	0	0.59	0.59	0.60	0.60
West Bengal Power Development Corporation	0.63	0.63	0.65	0.73	0.74	0.75	0.75
Average	**0.75**	**0.77**	**0.77**	**0.76**	**0.77**	**0.78**	**0.74**

* revised estimates

† Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 101
New Delhi Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (finance - costs and revenues)]

Table 11

Secondary oil consumption (ml/kWh of generation) in coal-based thermal units 1992/93 to 1998/99

State electricity board/agency	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	3.10	2.89	3.08	2.96	2.56	3.49	3.78
Assam	76.64	0.00	0.00	22.95	39.23	54.39	39.89
Bihar	23.70	20.13	21.79	23.94	36.43	24.05	25.51
Delhi Vidyut Board	25.10	0.00	0.00	17.81	23.87	13.39	14.56
Gujarat	8.89	6.91	9.27	12.21	10.85	8.22	7.11
Haryana	12.65	15.22	14.15	16.13	17.41	15.80	14.15
Himachal Pradesh	0	0	0	0	0	0	0
Jammu and Kashmir	0	0	0	0	0	0	0
Karnataka	0	0	0	0	0	0	0
Karnataka Power Corporation	0.90	0.90	0.75	1.39	0.76	2.00	2.00
Kerala	0	0	0	0	0	0	0
Madhya Pradesh	14.26	9.67	12.49	7.72	5.15	5.01	4.45
Maharashtra	5.64	4.64	4.80	4.07	4.07	3.63	3.52
Meghalaya	0	0	0	0	0	0	0
Orissa	10.20	7.76	13.76	17.03	0	0	0
Punjab	3.27	3.39	5.83	4.27	3.51	3.51	3.66
Rajasthan	3.83	3.40	4.23	3.83	2.52	3.00	3.23
Tamil Nadu	2.31	2.35	1.21	24.25	5.14	4.60	4.63
Uttar Pradesh	7.47	7.19	7.54	4.98	3.86	5.69	5.95
West Bengal	8.20	0	0	4.64	3.80	4.22	4.28
West Bengal Power Development Corporation	9.00	7.31	7.12	6.16	4.73	4.70	4.70
Average	**7.82**	**5.61**	**6.64**	**10.80**	**10.55**	**9.95**	**9.03**

* revised estimates

† Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 102.
New Delhi Power and Energy Division, Planning Commission, Government of India.

Table 12

Cost of fuels (coal and oil) per unit (paise/kWh) of electricity generation: 1990/91 to 1998/99

State electricity board/agency	Cost of coal per unit of generation									Cost of oil per unit of generation								
	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98 *	1998/99	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98 *	1998/99 †
Andhra Pradesh	34.57	41.61	51.56	61.38	64.46	69.17	77.36	83.68	85.52	1.13	1.40	1.50	1.77	1.86	1.76	1.57	2.62	2.98
Assam	60.60	65.00	0.00	0.00	0.00	98.93	114.24	128.49	139.80	25.20	40.93	0.00	0.00	0.00	13.94	28.10	41.89	31.55
Bihar	39.10	38.15	40.10	45.76	48.51	56.76	62.34	48.30	63.05	16.90	13.50	12.00	13.16	12.77	13.53	24.25	15.85	16.95
Delhi Vidyut Board	44.65	70.78	79.00	0.00	0.00	108.88	118.75	133.94	145.64	28.41	11.41	10.30	0.00	0.00	9.84	17.03	14.86	16.59
Gujarat	33.82	63.02	66.61	83.61	99.75	89.22	104.68	132.07	145.64	10.10	15.70	3.90	3.91	5.34	6.94	18.89	7.10	6.56
Haryana	70.00	61.72	0.00	102.52	108.01	0	0	1.21	1.21	4.30	6.80	0.00	0.00	0.00	0.00	0.00	0.10	0.09
Himachal Pradesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jammu and Kashmir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Karnataka	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Karnataka Power Corporation	46.26	51.36	61.60	61.60	68.55	84.46	93.99	101.24	101.25	1.00	1.31	0.40	0.40	0.37	0.99	0.69	1.60	1.60
Kerala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madhya Pradesh	17.59	21.72	29.30	32.73	40.63	44.65	57.13	63.28	63.26	4.45	4.98	7.20	5.66	7.68	4.79	3.57	3.93	3.49
Maharashtra	36.10	40.75	49.06	56.77	59.03	60.85	72.18	80.27	83.39	3.00	2.38	3.27	3.58	3.62	2.56	2.70	2.74	2.65
Meghalaya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orissa	20.00	18.56	28.00	28.39	31.85	28.41	0	0	0	3.80	6.95	6.00	5.61	10.12	19.93	0.00	0.00	0.00
Punjab	54.40	53.33	68.70	86.30	91.75	100.85	108.00	128.05	129.68	1.40	1.40	1.60	2.74	3.14	2.33	2.09	2.75	2.88
Rajasthan	58.00	36.47	65.40	71.14	0.00	0	98.26	115.18	118.29	6.00	4.18	1.60	1.65	0	0	1.52	2.00	2.16
Tamil Nadu	68.55	71.74	86.80	93.33	96.51	97.60	111.48	123.06	35.67	1.38	1.25	1.20	1.32	0.75	10.40	4.57	5.07	8.56
Uttar Pradesh	31.30	32.17	42.90	49.81	48.26	50.79	52.12	66.23	67.50	2.10	2.32	3.90	4.25	5.22	3.18	2.91	4.65	4.89
West Bengal	42.20	48.50	53.00	0	0	66.37	81.28	90.36	90.52	5.20	4.79	4.50	0	0	3.68	3.34	4.46	4.51
West Bengal Power Development Corporation	35.31	38.12	45.30	51.20	58.00	61.12	71.83	94.41	94.19	4.00	4.56	5.30	4.60	5.00	4.38	3.91	4.37	4.37
Average	**40.18**	**42.80**	**53.35**	**64.20**	**66.63**	**70.09**	**83.84**	**89.44**	**94.09**	**3.81**	**5.15**	**3.70**	**3.54**	**3.97**	**6.80**	**7.95**	**7.32**	**7.04**

* revised

† annual plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 103–104
New Delhi Power and Energy Division, Planning Commission, Government of India

Table 13

Details of nuclear power projects, 31 March 1995

Project	District and state	Number of units and capacity (MW)	Total capacity (MW)
* **Under operation**			
Tarapur (units 1 and 2)	Thane, Maharashtra	2 x 160	320
Rajasthan (unit 1)	Kota, Rajasthan	1 x 100	100
Rajasthan (unit 2)	Kota, Rajasthan	1 x 200	200
Chennai (units 1 and 2)	Chengalpettu, Tamil Nadu	2 x 220	440
Narora (units 1 and 2)	Bulandshahr, Uttar Pradesh	2 x 220	440
Kakrapar	Gujarat	2 x 220	440
Total			**1940**
Under construction			
Kaiga (units 1 and 2)	Uttar Kannada, Karnataka	2 x 220	440
Rajasthan (units 3 and 4)	Kota, Rajasthan	2 x 220	440
Total			**880**
Approved for construction and future projects			
Kaiga (units 3 to 6)	Uttar Kannada, Karnataka	4 x 220	880
Tarapur (units 3 and 4)	Thane, Maharashtra	2 x 500	1000
Rajasthan (units 5 and 6)	Kota, Rajasthan	2 x 500	1000
Kundankulam (units 1 and 2)	Tirunelveli, Tamil Nadu	2 x 1000	2000
Grand total			7700

* represents capacities

Source

CEA 1995 Vidyut Bharti, JulySeptember 1995 p 51 New Delhi Central Electricity Authority 56 pp

For more details, please see TEDDY ONLINE+ [Section Power (generation–nuclear)]

Table 14

Potential and development of hydroelectric power projects (MW) in different regions 31 March 1996

Region	Hydroelectric potential at 60% load factor	Hydroelectric potential under development (equivalent to 60% load factor)	Hydroelectric potential under developed (equivalent to 60% load factor)
North	30155	2204 6 (7 3)	4138 2 (13 7)
West	5679	1536 1 (27 1)	1818 8 (32 0)
South	10763	1108 2 (10 3)	5293 8 (49 2)
East	5590	720 (12 9)	908 8 (16 3)
North-east	31857	309 9 (1 0)	315 5 (1 0)
All-India total	**84044**	**5878.8 (7.0)**	**12475 1 (14.8)**

Note

Figures in parentheses indicate percentages

Source

CEA 1994 Review of Performance of Hydro Power Stations, 1995/96 p 1 New Delhi Hydro Electric Development Potential Directorate, Hydro Wing, Central Electricity Authority 172 pp

For more details, please see TEDDY ONLINE+ [Section Power (generation–hydro)]

Table 15

Potential and development of hydroelectric power projects (MW) of different basins 31 March 1996

River basin	Hydroelectric potential at 60% load factor	Hydroelectric potential under development (equivalent to 60% load factor)	Hydroelectric developed potential (equivalent to 60% load factor)
Indus	19988	1224 1 (6 1)	2761 6 (13 8)
Ganga	10715	1000 2 (9 3)	1841 6 (17 2)
Central Indian rivers	2740	1531 3 (55 9)	631 (23 0)
West-flowing rivers	6149	1006 3 (16 4)	3191 8 (51 9)
East-flowing rivers	9532	694 (7 3)	3658 1 (38 4)
Brahmaputra	34920	422 8 (1 2)	391 (1 1)
Total	**84044**	**5878.7 (7.0)**	**12475.1 (14.8)**

Note

Figures in parentheses indicate percentages

Source

CEA 1994 Review of Performance of Hydro Power Stations, 1995/96 p 2 New Delhi Hydro Electric Development Potential Directorate, Hydro Wing, Central Electricity Authority 172 pp

For more details, please see TEDDY ONLINE+ [Section Power (generation–hydro)]

Table 16

Length of transmission and distribution lines (circuit km) by region and state: 31 March 1996

† Region/state	*Total*	*400 kV*	*230 kV*	*220 kV*	*132 kV*	*110/90 kV*	*78/66 kV*	*33 kV*	*22/20 kV*	*15/11 kV*	*6.6 kV*	*3.3/2.2 kV*	*Distribution lines up to 500 V*
Northern region													
Haryana	164556	0	0	860	2070	0	1540	4288	0	53159	0	0	102639
* Himachal Pradesh	59112	0	0	192	455	0	330	1959	4001	11364	0	0	40697
* Jammu and Kashmir	41884	0	0	224	659	0	0	1693	0	11538	0	0	27770
Punjab	237193	574	0	5559	2939	0	3755	1494	0	77931	70	0	144819
Rajasthan	341600	0	0	5221	8777	0	303	21105	0	127102	56	0	179022
Uttar Pradesh	450171	2049	0	5867	10147	0	3139	24374	0	184268	0	14	220022
Chandigarh	1752	0	0	0	0	0	61	0	0	654	0	0	1009
Delhi	32718	0	0	401	0	0	608	500	0	3172	0	28	22203
Central sector	8467	4735	0	2102	0	0	0	0	0	0	0	0	0
Sub-total	**1337453**	**7358**	**0**	**20426**	**25047**	**0**	**9736**	**55413**	**4001**	**469188**	**126**	**42**	**738181**
Western region													
Gujarat	313625	1304	0	7673	4199	0	11263	150	5441	109823	0	0	171547
Madhya Pradesh	595914	1515	0	7724	11461	0	362	32745	0	189444	0	49	350659
Maharashtra	475710	4488	0	8451	7641	2817	3264	16446	16837	128793	49	0	284152
Goa	8498	0	0	24	0	198	0	786	0	2201	0	0	5289
Dadra and Nagar Haveli	1262	0	0	0	0	0	42	0	0	157	0	0	63
Daman and Diu	271	0	0	0	0	0	59	0	0	355	0	0	848
Central sector	5062	4234	0	828	0	0	0	0	0	0	0	0	0
Sub-total	**1400342**	**11541**	**0**	**24700**	**23301**	**3015**	**14990**	**50127**	**22278**	**430773**	**49**	**49**	**812558**
Southern region													
Andhra Pradesh	607412	0	0	7189	9954	0	633	25069	0	156347	0	0	407653
Karnataka	447816	910	0	6295	0	5157	4628	5175	0	112608	0	0	312054
Kerala	156536	0	0	1070	0	2444	2565	0	0	24702	0	0	125755
Tamil Nadu	541616	0	5507	0	0	9401	2706	4030	29779	68874	0	0	392767
Lakshadweep	209	0	0	0	0	0	0	0	0	0	0	9	170
Pondicherry	4571	0	0	63	0	158	0	0	616	224	0	0	3482
Central Sector	5521	5457	0	64	0	0	0	0	0	0	0	0	0
Sub-total	**1736681**	**6367**	**5507**	**14681**	**9954**	**17160**	**10532**	**34274**	**30395**	**362755**	**0**	**9**	**1241881**
Eastern region													
Bihar	179830	233	0	1532	4441	0	0	8876	0	73791	0	0	90957
Orissa	117628	242	0	3137	4211	0	136	9831	0	48359	0	0	51510
West Bengal	157356	267	0	2801	3365	0	806	6213	0	65527	18	22	74489
Damodar Valley Corporation	5477	0	0	1019	3406	0	0	1052	0	0	0	0	0
Andaman and Nicobar Islands	4095	0	0	0	0	0	0	215	0	817	0	0	3063
* Sikkim	4460	0	0	0	0	0	29	0	0	1692	0	4	2735
Central sector	3499	2341	0	1158	0	0	0	0	0	0	0	0	0
Sub-total	**472345**	**3083**	**0**	**9647**	**15423**	**0**	**971**	**26187**	**0**	**190186**	**18**	**26**	**222754**
North-eastern region													
Assam	79855	0	0	1024	1277	0	159	4982	0	32543	0	0	39870
Manipur	10511	0	0	0	309	0	0	541	0	4958	0	0	4703
Meghalaya	13341	0	0	0	552	0	0	1038	0	6331	0	0	5420
Nagaland	10569	0	0	0	240	0	236	1874	0	4007	0	0	4212
* Tripura	10459	0	0	0	150	0	308	443	0	4261	0	0	5297
Arunachal Pradesh	10377	0	0	0	0	0	0	2832	0	2896	0	0	4649
* Mizoram	6850	0	0	0	323	0	110	687	0	3413	0	0	2317
Central sector	913	0	0	218	695	0	0	0	0	0	0	0	0
Sub-total	**142875**	**0**	**0**	**1242**	**3546**	**0**	**813**	**12397**	**0**	**58409**	**0**	**0**	**66468**
All-India total	**5089696**	**28349**	**5507**	**70696**	**77271**	**20175**	**37042**	**178398**	**56674**	**1511311**	**193**	**126**	**3081842**

* data repeated

† includes union territory also

Source

CEA. 1999 Public Electricity Supply, All India Statistics, General Review, 1993/94,1994/95, and 1995/96 pp 153–156 New Delhi Central Electricity Authority 214 pp

For more details, please see TEDDY ONLINE+ [Section. Power (transmission)]

Table 17

Transmission and distribution losses as a percentage of availability in state electricity departments: 1990/91 to 1998/99

State	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	22.9	20.3	19.2	19.1	18.9	18.9	30.5	25.0	23.0
Arunachal Pradesh	20.0	28.2	34.9	31.6	31.0	36.0	32.0	30.0	32.0
Assam	24.1	22.7	21.0	20.8	24.9	26.2	24.9	24.0	23.0
Bihar	16.5	18.3	20.5	19.0	24.0	25.9	25.3	23.0	23.0
Daman and Diu	16.9	15.9	0	0	0	0	0	0	0
Goa	25.0	23.8	20.8	21.8	26.2	28.5	26.7	26.0	25.0
Gujarat	23.4	23.6	21.1	21.3	20.0	18.3	18.2	18.0	17.0
Haryana	27.5	26.8	25.4	25.5	28.5	31.4	31.7	32.2	31.1
Himachal Pradesh	21.0	19.2	18.5	17.3	17.4	17.5	17.9	17.4	16.7
Jammu and Kashmir	43.0	50.1	45.3	47.7	46.9	48.6	48.0	47.5	47.0
Karnataka	20.2	19.3	18.7	18.6	18.9	18.5	18.5	18.4	17.4
Kerala	22.4	22.5	21.0	20.2	20.1	20.1	20.0	19.0	18.0
Lakshadweep	18.6	17.4	0	0	0	0	0	0	0
Madhya Pradesh	18.0	25.8	22.2	20.2	20.1	19.5	19.3	19.0	18.5
Maharashtra	18.3	18.6	16.4	15.8	15.3	15.4	15.3	15.2	15.2
Manipur	28.0	24.4	22.5	22.5	22.0	21.5	21.5	21.5	21.0
Meghalaya	11.5	11.7	12.2	10.7	18.7	17.8	19.3	16.9	16.0
Mizoram	29.6	34.9	28.1	28.0	28.0	27.0	26.0	26.0	25.0
Nagaland	26.1	23.1	32.4	31.6	30.8	30.0	29.7	29.0	28.5
Orissa	25.8	25.3	23.5	23.4	23.8	46.9	45.1	39.0	35.0
Punjab	19.3	21.8	18.7	18.5	18.3	18.2	18.0	18.0	17.8
Rajasthan	25.8	23.1	24.5	25.2	25.0	28.5	25.3	23.0	22.5
* Sikkim	24.5	25.9	21.8	21.5	21.2	21.0	20.2	20.0	20.0
Tamil Nadu	18.0	18.4	17.5	17.3	16.9	17.0	17.0	17.0	17.0
Tripura	29.6	32.0	30.5	30.0	30.0	30.0	30.0	29.8	29.0
Uttar Pradesh	27.1	26.1	24.1	23.2	22.6	22.8	24.6	23.0	21.0
West Bengal	17.7	19.7	23.7	22.4	21.1	20.7	20.1	19.7	18.9
'All-India (utilities)	**22.9**	**22.8**	**19.8**	**20.2**	**20.3**	**22.2**	**23.0**	**21.8**	**20.8**

* revised
† estimate

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 63
New Delhi. Power and Energy Division, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (transmission)]

Table 18

Villages electrified and rural population benefited by electricity in different region and state. 1996 to 1998

Region/state	*Total number of villages (31 March 1996)*	*Total electrified (31 March 1996)*	*Electrified (%) (31 March 1996)*	*Population covered (1981 census) (%) (31 March 1996)*	*Number of villages electrified cumulative in March 1998*
North					
Haryana	6745	6745	100.00	100.00	6759
Himachal Pradesh	16807	16761	99.70	100.00	16635
Jammu and Kashmir	6477	6274	96.86	54.80	6315
Punjab	12342	12342	100.00	100.00	12428
Rajasthan	34968	30620	87.60	92.40	34252
Uttar Pradesh	112566	86639	76.96	90.60	87930
Chandigarh	24	24	100.00	100.00	0
Delhi	214	214	100.00	100.00	0
Sub-total	**190143**	**159619**	* **83.95**	**91.50**	**164319**
West					
Gujarat	18114	17892	100.00	100.00	17936
Madhya Pradesh	71352	67741	94.94	77.95	67959
Maharashtra	39354	39106	100.00	100.00	40412
Goa	386	377	100.00	100.00	360
Daman and Diu	26	26	100.00	100.00	0
Dadra and Nagar Haveli	70	67	100.00	100.00	0
Sub-total	**129302**	**125209**	**96.83**	**91.41**	**126667**
South					
Andhra Pradesh	27379	27358	100.00	100.00	26565
Karnataka	27028	26483	100.00	100.00	26663
Kerala	1219	1219	100.00	100.00	1384
Tamil Nadu	15831	15822	100.00	100.00	15822
Lakshadweep	7	7	100.00	100.00	0
Pondicherry	291	291	100.00	100.00	0
Sub-total	**71755**	**71180**	**100.00**	**100.00**	**70434**
East					
Bihar	67546	47805	70.77	36.80	47837
Orissa	46553	33871	72.76	81.70	33625
West Bengal	38024	29205	76.80	63.47	29319
Andaman and Nicobar Islands	491	491	100.00	100.00	0
Sikkim	440	405	100.00	100.00	405
Sub-total	**153054**	**111777**	**73.03**	**53.89**	**111186**
North-east					
Assam	21995	21887	99.50	67.70	19019
Manipur	2035	2016	99.10	67.90	1940
Meghalaya	4902	2407	49.10	63.30	2494
Nagaland	1112	1099	98.80	99.70	1153
Tripura	856	3640	77.00	71.33	803
Arunachal Pradesh	3257	2270	69.69	33.90	2161
Mizoram	721	727	100.00	75.00	684
Sub-total	**34878**	**34046**	**97.61**	**67.94**	**28254**
All-India	**579132**	**501831**	**86.66**	**83.43**	**500860**

* includes union territory also

Sources

1 Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 63
New Delhi Power and Energy Division, Government of India

2 MoP 1999 Annual Report 1998/99 New Delhi Central Electricity Authority, Ministry of Power

For more details, please see TEDDY ONLINE + [Section Power (rural)]

Table 19

Energization of pumpsets: March 1995 to March 1998

State/union territory	*Energization of pumpsets* *Cumulative (March 1995)*	*Cumulative (March 1996)*	*Cumulative (March 1997)*	*Cumulative (March 1998)*
Andhra Pradesh	1605807	1642993	1821291	1824689
Assam	0	3675	3675	3675
Bihar	264755	267371	269345	270277
Goa	5441	5732	6063	6454
Gujarat	551551	568858	591564	617495
Haryana	404107	406612	408461	409404
Himachal Pradesh	4141	4441	4780	5098
Jammu and Kashmir	3586	4716	5088	5621
Karnataka	973288	1014918	1049465	1082150
Kerala	289866	304904	314632	329355
Madhya Pradesh	1087404	1131435	1176317	1229016
Maharashtra	1883152	2025973	2091718	2151191
Manipur	45	45	45	45
Meghalaya	65	65	65	65
Mizoram	0	0	0	0
Nagaland	176	176	176	176
Orissa	65145	69184	70144	72047
Punjab	681432	709916	726221	735162
Rajasthan	488770	514758	539762	565068
Sikkim	0	0	0	0
Tamil Nadu	1487654	1528807	1567322	1609242
Tripura	1738	1764	1764	1764
Uttar Pradesh	727937	761272	778512	790157
West Bengal	98329	101232	102773	104383
Total (states)	**10585006**	**11068847**	**11529183**	**11812534**
Total (union territories)	**34578**	**35243**	**36159**	**36872**
Grand total	**10619584**	**11104090**	**11565342**	**11849406**

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p. 79 New Delhi Power and Energy Division, Planning Commission, Government of India

Table 20

Progress in rural electrification: 1970/71 to 1997/98

Item	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Villages electrified (thousands)	104.9	272.3	390.3	481.1	487.2	490.8	494.2	497.7	495.7	498.6	502.0
As per cent of total number of villages (%)	18.5	47.3	67.7	83.1	84.1	84.8	85.3	86.0	86.7	0	0
Pumpsets energized (thousands)	1629.4	4330.5	6152.0	8909.1	9391.1	9851.2	10276.6	10721.3	11104.1	11565.3	11849.4

Sources

1 CEA. 1995 Public Electricity Supply, All India Statistics, General Review, 1995/96. pp 210–213. New Delhi Central Electricity Authority 214 pp

2 MoP 1998 Annual Report 1997/98 New Delhi Ministry of Power.

3 Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p 78–79 New Delhi Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (rural)]

Table 21

Number of towns electrified for various population groups: 1970/71 to 1995/96

Population	*1970/71*	*1980/81* *	*1985/86* †	*1990/91* †	*1991/92* ‡	*1992/93* ‡	*1993/94* ‡	*1994/95* ‡	*1995/96* ‡
5000 and below	266	296	297	297	356	356	356	356	356
5001 to 9999	844	820	820	820	943	943	943	943	943
10000 to 19999	819	987	987	987	1273	1273	1273	1273	1273
20000 to 49999	518	652	652	652	892	892	892	892	892
50000 to 99999	139	219	219	219	330	330	330	330	330
100000 and above	107	151	151	151	227	227	227	227	227
Total	**2693**	**3125**	**3126**	**3126**	**4021**	**4021**	**4021**	**4021**	**4021**

* number of towns based on 1961 census

† number of towns based on 1971 census

‡ number of towns based on 1981 census

Source

CEA 1995 Public Electricity Supply, All India Statistics, General Review, 1995/96 pp 208–209 New Delhi· Central Electricity Authority. 214 pp

For more details, please see TEDDY ONLINE+ [Section: Power (rural)]

Table 22

Cost structure (paise/kWh of sale) of state electricity boards: 1998/99

State electricity board/agency	Fuel	Power purchase	Operation and maintenance	Establishment/ administration	Miscellaneous expenses	Depreciation	Interest	Total
Andhra Pradesh	58.30	78.43	8.03	22.84	3.11	18.38	44.92	**234.00**
Assam	68.40	123.16	11.20	62.62	3.92	26.89	124.36	**420.56**
Bihar	29.78	148.03	11.95	41.16	0	21.05	16.75	**268.71**
Delhi Vidyut Board	35.06	259.88	11.08	45.72	0	14.58	0.00	**366.32**
Gujarat	99.03	112.06	6.59	18.26	0	13.74	12.30	**261.98**
Haryana	51.80	97.56	13.26	56.44	0	28.31	31.36	**278.73**
Himachal Pradesh	0.00	57.59	21.60	55.30	0	6.66	35.16	**176.31**
Jammu and Kashmir	6.75	181.10	6.19	23.57	0	16.10	13.34	**247.06**
Karnataka	8.75	109.75	8.42	37.58	2.47	15.91	24.66	**207.54**
Karnataka Power Corporation	39.75	0	3.23	8.16	2.62	11.99	32.13	**97.88**
Kerala	18.69	58.85	60.09	0	2.85	9.43	51.64	**201.56**
Madhya Pradesh	44.35	76.23	9.57	34.66	4.90	22.68	38.15	**230.54**
Maharashtra	71.39	59.80	13.81	29.86	1.53	23.97	26.13	**226.49**
Meghalaya	0	35.60	26.24	103.74	0	13.86	227.58	**407.02**
Orissa	0	183.18	9.49	42.73	0.19	21.12	24.06	**280.77**
Punjab	78.59	38.77	7.25	47.38	0.75	19.14	46.08	**237.95**
Rajasthan	57.49	84.38	8.06	26.59	23.11	16.84	48.13	**264.62**
Tamil Nadu	101.96	50.40	5.75	44.20	4.17	17.46	20.21	**244.16**
Uttar Pradesh	49.43	61.67	11.50	35.18	0.31	29.38	58.79	**246.25**
West Bengal	34.23	148.70	9.97	38.17	4.02	14.25	27.99	**277.33**
West Bengal Power Development Corporation	109.03	0	12.92	0	0	18.58	25.01	**165.54**
Average	**59.40**	**82.62**	**10.83**	**31.76**	**2.90**	**19.45**	**33.10**	**239.68**

Source

Planning Commission. 1999. Annual Report on the Working of State Electricity Boards and Electricity Departments. p. 100 New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (finance-costs and revenues)]

Table 23

Unit cost of power supply (paise/kWh): 1990/91 to 1998/99

State electricity board/agency	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Andhra Pradesh	78.72	89.23	100.07	109.00	128.93	156.12	20.5.12	217.44	234.00
Assam	249.59	281.24	255.22	252.65	299.30	356.07	402.17	423.17	420.28
Bihar	168.97	176.53	185.67	200.05	232.84	252.40	290.55	295.28	268.71
Delhi Vidyut Board	137.89	144.06	164.12	—	—	329.76	332.73	365.02	380.85
Gujarat	110.11	132.28	146.59	158.40	171.63	181.53	199.66	235.37	261.74
Haryana	103.66	115.47	134.40	165.40	179.53	208.69	230.51	244.09	278.68
Himachal Pradesh	94.77	118.19	114.31	142.80	126.60	111.45	129.36	160.17	175 99
Jammu and Kashmir	125.59	172.34	165 46	209.13	230.80	242.48	282.38	290.47	277.00
Karnataka	82.55	92.02	96.77	112.10	121.11	152.34	194.19	188.59	206.61
Karnataka Power Corporation	31.35	30.97	42.64	43.58	41.92	69.75	99.96	83.92	102.91
Kerala	68.17	81.30	87.30	98.32	108.84	134 46	169.92	199.04	230.52
Madhya Pradesh	116.44	121.53	141.44	157.80	167 18	181 64	208.71	218 12	231.38
Maharashtra	107.44	124.51	138.95	152.24	162 02	185 25	206.85	218.24	236.68
Meghalaya	137.28	107.06	110.09	97.75	139.01	147 35	158 59	168.19	405.04
Orissa	71.43	71.77	98.80	133.46	185.70	227.46	263.80	272.03	280.77
Punjab	106.79	98.77	122.00	145.16	165.06	179.69	187.44	226 64	238 95
Rajasthan	114.59	113.31	138.24	163 80	196.52	213.17	239.49	259 57	264 67
Tamil Nadu	114.32	103.33	124.52	144.72	152.02	170.91	185 00	217 06	244.18
Uttar Pradesh	110.04	119.51	153.42	169.44	177.53	191 98	222.33	239.59	246.26
West Bengal	157.19	163.69	161.90	170.05	185.21	189 39	204.10	254.70	277.33
West Bengal Power Development Corporation	69 55	73.12	82.90	90 40	110.34	109.03	136 53	163.40	161 95
Average	**108.59**	**116.80**	**128.15**	**149.12**	**163.40**	**179.60**	**207.11**	**225.21**	**242.85**

Source

Planning Commission 1999. Annual Report on the Working of State Electricity Boards and Electricity Departments. p 93 New Delhi: Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (finance-costs and revenues)]

Table 24

Consumer categorywise average tariff of electricity (paise/kWh): 1998/99

State electricity board/agency	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industrial*	*Railway traction*	*Outside state*	*Overall average*
Andhra Pradesh	167 00	367 80	16.10	330.30	374.30	80 00	188.10
Assam	146.00	297.00	156.60	233.00	—	—	216 80
Bihar	109.30	211 40	14 00	275 90	313.00	177 60	210 80
Delhi Vidyut Board	258 70	237 00	116 00	299.40	—	—	270.70
Gujarat	254 00	424.00	20.00	396.50	421 00	—	325 00
Haryana	241.00	341.00	55.00	341.00	341 00	138 00	180.50
Himachal Pradesh	70 00	230.00	60 00	194.00	—	190.00	172.70
Jammu and Kashmir	40.80	74.00	15.80	59 00	—	—	50.00
Karnataka	144.00	545.00	86.00	325 00	330 00	—	188 70
Kerala	83.40	295 70	55.10	165 90	—	—	173 20
Madhya Pradesh	74 50	337.50	9.10	385 10	529.40	101.30	168.50
Maharashtra	156 30	365.30	25.40	351.20	363.20	175.80	214 10
Meghalaya	93.30	181.20	50.00	184.70	—	173 70	156.90
Orissa	141 00	281.00	72.00	277.50	421 00	—	240.00
Punjab	150 20	278.50	—	243.20	—	190.00	146 70
Rajasthan	144 00	308 00	38 00	311.80	320.00	219.50	198.50
Tamil Nadu	166.70	459.40	—	365.90	380.30	211.30	224.70
Uttar Pradesh	108.90	360.00	46.60	341.60	390.40	7 30	171.90
West Bengal	108.50	246.10	34.10	283.70	328.50	318.30	218.00
Average	**131.10**	**345.29**	**29.66**	**297.53**	**398.86**	**156.65**	**197.85**

Source

Planning Commission 1999. Annual Report on the Working of State Electricity Boards and Electricity Departments p. 125 New Delhi. Power and Energy Division, Planning Commission, Government of India

Table 25

Average tariff for sale of electricity (paise/kWh): 1990/91 to 1998/99

State electricity board	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	74.5	83.3	94.3	98.6	92.9	97.1	150.0	188.5	188.1
Assam	94.8	92.1	121.0	121.3	121.5	214.7	214.9	216.6	216.8
Bihar	88.6	97.8	118.4	147.4	155.0	179.1	185.2	210.7	210.8
Delhi Vidyut Board	99.1	124.7	134.0	—	—	—	248.6	265.1	270.7
Gujarat	78.0	93.0	100.3	121.0	128.0	132.0	162.0	193.0	325.0
Haryana	66.6	66.3	72.5	83.3	110.8	132.8	155.3	178.8	180.5
Himachal Pradesh	79.1	86.0	101.1	106.8	116.3	122.1	143.5	162.3	172.7
Jammu and Kashmir	35.9	35.9	35.3	35.1	36.7	35.6	34.2	39.3	50.0
Karnataka	81.3	82.4	93.4	106.8	105.1	114.1	140.6	163.7	188.7
Kerala	52.6	60.0	74.0	82.1	86.7	92.8	95.6	126.9	173.2
Madhya Pradesh	84.9	94.9	118.9	118.9	129.6	139.3	177.2	176.2	168.5
Maharashtra	103.1	107.8	136.9	150.5	161.1	169.0	189.0	213.8	214.1
Meghalaya	59.2	64.6	89.5	91.4	98.9	107.2	127.7	130.0	156.9
Orissa	67.9	65.1	77.2	95.1	149.8	170.3	202.0	218.0	240.0
Punjab	54.9	59.9	70.3	89.3	108.3	124.9	136.3	139.7	146.7
Rajasthan	92.9	93.1	105.1	115.3	133.3	142.3	166.6	194.9	198.5
Tamil Nadu	86.5	96.1	107.1	128.3	150.2	165.9	172.9	197.1	224.7
Uttar Pradesh	73.1	79.7	108.4	111.8	122.4	140.8	143.0	171.5	171.9
West Bengal	104.2	111.9	115.7	135.4	143.0	147.9	151.6	194.0	218.0
Average	**81.8**	**89.1**	**105.4**	**116.7**	**128.0**	**139.9**	**163.0**	**184.5**	**197.9**

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Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 118
New Delhi Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE + [Section Power (finance–tariff)]

Table 26

Effective subsidy for agricultural consumers (million rupees). 1992/93 to 1998/99

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	7259	9254	13503	17477	16788	18155	21428
Assam	62	88	11	87	60	141	163
Bihar	2676	2519	2971	2995	3507	3908	4478
Delhi	86	0	0	0	0	0	254
Gujarat	10554	12060	12662	16468	18126	25039	31806
Haryana	4563	5400	4898	6123	7274	7427	8898
Himachal Pradesh	10	15	9	7	9	14	16
Jammu and Kashmir	275	534	668	706	907	1167	1319
Karnataka	4965	6679	8707	11092	9100	8252	9228
Kerala	0	164	230	357	470	517	672
Madhya Pradesh	4211	7562	11037	14164	17249	18542	20463
Maharashtra	10309	11309	16470	22498	25536	28758	33731
Meghalaya	0	1	1	2	2	2	7
Orissa	207	392	202	303	408	483	574
Punjab	6871	7973	7809	8285	10083	14731	15532
Rajasthan	3475	4684	6226	8076	10550	10409	11474
Tamil Nadu	6425	7598	9468	11333	12802	15617	17823
Uttar Pradesh	10354	12274	12751	14024	17623	18900	2019
West Bengal	1042	1150	1688	2065	2496	3249	3916
Total	73349	89656	109410	136060	152990	175313	201973

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Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 131
New Delhi Power and Energy Division, Planning Commission, Government of India

Table 27

Subsidy for domestic consumers (million rupees): 1992/93 to 1998/99

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	404	636	1187	1593	2380	2558	3682
Assam	372	824	793	901	1191	1189	1635
Bihar	400	563	892	1189	1583	1779	1929
Delhi	2974	0	0	0	0	0	4227
Gujarat	880	949	1218	1361	1122	921	228
Haryana	956	1372	1132	1231	1096	110	681
Himachal Pradesh	137	259	232	199	296	451	530
Jammu and Kashmir	495	620	700	938	1277	1564	1630
Karnataka	225	92	353	1185	2523	2207	2114
Kerala	605	834	1147	2040	3748	3443	4830
Madhya Pradesh	2527	2584	3154	4015	5104	5929	7149
Maharashtra	1516	1933	1902	3267	4238	2955	4574
Meghalaya	14	11	28	59	67	76	296
Orissa	804	1224	921	1435	1963	2283	2534
Punjab	543	831	1081	1196	1623	2521	3207
Rajasthan	1833	1275	1634	2207	2180	2648	2979
Tamil Nadu	1418	1476	1586	1927	2375	3046	3379
Uttar Pradesh	3318	4685	5635	5575	8071	9877	11354
West Bengal	929	1140	1773	1926	2588	3293	3854
Total	20349	21308	25368	32244	43428	46850	60812

* revised
† Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p. 134. New Delhi Power and Energy Division, Planning Commission, Government of India.

Table 28

Cross-subsidy from other users (million rupees): 1992/93 to 1998/99

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	6680	7815	6497	5328	7252	13214	12532
Assam	–1480	–1154	–1293	–1729	–2287	3813	–2019
Bihar	–660	–187	–1061	–557	–3252	2679	983
Delhi	710	0	0	0	0	0	–5955
Gujarat	3190	5386	4507	5659	9556	13343	19711
Haryana	230	422	800	1515	2360	2690	1811
Himachal Pradesh	–67	–221	52	322	466	1283	–85
Jammu and Kashmir	–1180	–1650	–2102	–1995	–2890	–3558	–3713
Karnataka	4750	5987	6516	6268	6473	12416	14221
Kerala	–15	–16	–181	–179	–432	1674	0
Madhya Pradesh	3100	4453	6519	9623	15072	14578	12389
Maharashtra	11350	12624	17814	19007	25905	30282	27489
Meghalaya	3	52	–47	–42	–79	–40	–561
Orissa	–1667	–688	518	–750	–1015	–847	–101
Punjab	350	556	375	823	2907	1469	705
Rajasthan	870	651	391	1331	2817	3422	3847
Tamil Nadu	4610	5876	10799	12132	12225	13410	16005
Uttar Pradesh	9200	3948	4839	6007	5172	9901	10002
West Bengal	–864	30	115	575	94	789	1691
Total	**39110**	**45225**	**53792**	**63337**	**80342**	**112893**	**108951**

* revised
† Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p 137 New Delhi: Power and Energy Division, Planning Commission, Government of India

Table 29

Subsidy to sales revenue ratio (with cross-subsidization) (%): 1992/93 to 1998/99

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	6.1	10.5	38.8	60.8	36.8	15.4	23.5
Assam	111.0	101.4	85.7	74.9	87.8	107.8	57.7
Bihar	56.9	36.1	50.6	41.2	66.3	19.5	27.5
Delhi	22.4	0	0	0	0	0	40.7
Gujarat	46.1	30.5	34.0	37.2	23.4	22.2	16.4
Haryana	85.3	98.5	62.6	55.8	47.4	32.9	50.8
Himachal Pradesh	13.0	33.8	8.9	-6.1	-11.7	-22.4	10.8
Jammu and Kashmir	348.4	504.8	874.1	657.0	819.9	721.1	515.9
Karnataka	3.7	5.0	15.2	32.9	24.1	-7.1	-9.6
Kerala	18.1	19.8	25.6	37.4	69.3	22.7	36.2
Madhya Pradesh	19.0	24.0	29.0	26.1	17.8	23.6	37.3
Maharashtra	1.5	1.1	0.6	9.6	4.4	1.6	10.5
Meghalaya	24.2	6.9	40.5	37.6	24.3	29.3	158.2
Orissa	28.0	40.4	24.0	29.5	30.6	24.8	17.0
Punjab	71.7	61.8	49.9	43.4	36.5	62.3	62.9
Rajasthan	31.5	42.0	47.4	47.6	42.3	33.2	33.3
Tamil Nadu	16.1	12.8	1.2	3.0	7.0	10.1	8.7
Uttar Pradesh	41.6	51.5	45.0	39.2	55.5	40.1	43.2
West Bengal	39.9	27.6	35.7	27.4	34.6	30.2	27.1
Average	**25.6**	**27.0**	**28.2**	**29.1**	**26.9**	**20.6**	**25.6**

* revised

† Annual Plan

Source

Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p 135
New Delhi Power and Energy Division, Planning Commission, Government of India

Table 30

Sales revenue as a ratio of cost (%): 1992/93 to 1998/99

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *	*1998/99* †
Andhra Pradesh	94.2	90.5	72.1	62.2	73.1	86.2	80.6
Assam	47.4	49.7	53.9	57.1	53.4	51.2	63.3
Bihar	63.7	73.5	66.4	70.8	63.7	71.4	78.4
Delhi	81.7	0.0	0.0	70.6	72.0	72.6	71.1
Gujarat	68.4	76.6	74.6	72.9	81.1	81.9	85.9
Haryana	54.0	50.4	61.5	63.6	67.4	73.2	64.1
Himachal Pradesh	88.5	74.5	91.9	98.8	101.5	92.7	90.2
Jammu and Kashmir	21.3	16.7	10.3	13.2	10.9	12.2	16.2
Karnataka	96.5	95.3	86.8	74.9	72.4	86.8	89.9
Kerala	84.7	83.5	79.6	69.0	56.3	63.8	75.1
Madhya Pradesh	84.0	80.7	77.3	79.5	84.9	80.8	72.3
Maharashtra	98.5	88.8	99.4	91.2	96.2	97.9	90.5
Meghalaya	81.3	93.6	71.2	72.7	80.5	77.3	38.7
Orissa	78.1	71.2	80.7	77.1	75.2	80.1	85.5
Punjab	57.6	61.8	66.7	69.7	73.2	61.6	60.9
Rajasthan	76.0	70.4	67.8	67.8	69.6	75.1	74.5
Tamil Nadu	86.0	88.7	98.8	97.1	93.4	90.8	92.0
Uttar Pradesh	70.6	66.0	69.0	70.7	64.3	71.6	69.8
West Bengal	71.5	73.4	73.7	78.5	74.3	76.2	78.6
Average	**82.2**	**78.3**	**78.3**	**76.1**	**77.4**	**80.1**	**78.6**

* revised

† Annual Plan

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p 128.
New Delhi Power and Energy Division, Planning Commission, Government of India

Table 31

Percentage of unit cost of supply recovered from the consumer tariff by category: 1997/98

State electricity board	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industrial*	*Railway traction*	*Outside state*	*Overall average*
Andhra Pradesh	76.81	169.17	8.00	151.92	172.16	36.80	86.70
Assam	34.48	70.18	39.41	49.48	0.00	0.00	51.18
Bihar	37.02	71.59	4.74	93.44	106.00	60.15	71.36
Delhi	0	0	0	0	0	0	75.46
Gujarat	84.97	157.62	8.50	143.09	156.35	0	82.00
Haryana	97.50	138.47	22.53	138.47	138.47	56.53	73.25
Himachal Pradesh	37.50	131.24	31.25	114.24	0	112.49	101.43
Jammu and Kashmir	11.13	20.18	4.35	16.46	0	0	13.67
Karnataka	62.72	265.26	46.18	160.60	154.55	0	86.79
Kerala	46.50	149.65	27.88	83.97	0	0	70.76
Madhya Pradesh	34.36	155.67	4.61	185.33	244.19	46.73	81.27
Maharashtra	78.72	136.32	12.33	166.97	169.58	84.62	103.38
Meghalaya	50.26	95.96	29.99	98.30	0.00	77.67	77.97
Orissa	45.52	86.40	24.19	94.19	140.74	0	80.15
Punjab	65.67	122.52	0.00	106.88	0.00	84.19	61.90
Rajasthan	55.44	115.50	14.63	117.31	120.51	83.04	75.04
Tamil Nadu	67.36	185.67	0.00	148.08	153.70	85.37	90.81
Uttar Pradesh	45.46	147.76	18.66	140.04	160.45	3.05	71.59
West Bengal	36.99	84.03	11.66	96.87	112.15	108.69	76.18
Average	60.26	149.99	12.47	128.17	168.67	66.11	83.03

Source

Planning Commission. 1999. Annual Report on the Working of State Electricity Boards and Electricity Departments p. 125. New Delhi: Power and Energy Division, Planning Commission, Government of India

Table 31 A

Percentage of unit cost of supply recovered from the consumer tariff by category: 1998/99

State electricity board	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industrial*	*Railway traction*	*Outside state*	*Overall average*
Andhra Pradesh	71.37	157.18	6.88	141.15	159.96	34.19	80.38
Assam	34.72	70.62	37.24	55.40	0	0	51.55
Bihar	40.68	78.67	5.21	102.68	116.48	66.09	78.45
Delhi	70.62	64.70	31.67	81.73	0	0.00	73.78
Gujarat	96.95	161.84	7.63	151.35	160.70	0.00	124.06
Haryana	86.46	122.34	19.73	122.34	122.34	49.51	64.76
Himachal Pradesh	39.70	130.45	34.03	110.03	0	107.76	97.95
Jammu and Kashmir	16.51	29.95	6.40	23.88	0	0	20.24
Karnataka	69.38	262.60	41.44	156.60	159.01	0	90.92
Kerala	41.38	146.71	27.34	82.31	0	0	85.93
Madhya Pradesh	32.32	146.40	3.95	167.04	229.63	43.94	73.09
Maharashtra	69.01	161.29	11.21	155.06	160.36	77.62	94.53
Meghalaya	22.92	44.52	12.28	45.38	0	42.68	38.55
Orissa	50.22	100.08	25.64	98.84	149.94	0	85.48
Punjab	63.12	117.04	0	102.21	0	79.85	61.65
Rajasthan	54.42	116.39	14.36	117.83	120.93	82.95	75.01
Tamil Nadu	68.27	188.16	0	149.86	155.76	86.54	92.03
Uttar Pradesh	44.22	146.19	18.92	138.72	158.54	2.96	69.81
West Bengal	39.12	88.74	12.30	102.30	118.45	114.77	78.61
Average	54.70	144.06	12.37	124.14	166.41	65.36	82.55

Source

Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. p. 125. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 32

Number of consumers (thousands) and connected load (MW): 1970/71 to 1995/96

Category	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Number of consumers									
Domestic	10165.2	22337.6	33569.3	50389.3	53771.3	56664.2	60193.2	63409.3	66984.1
Commercial	2305.7	4582.1	6130.8	8002.1	8429.3	8772.5	9209.2	9558.2	9971.1
Industrial (low-and medium-tension)	532.3	1126.5	1596.6	2042.3	2144.4	2206.7	2301.6	2382.0	2425.5
Industrial (high-tension)	10.0	23.5	20.6	34.7	35.6	41.7	35.5	40.7	43.6
Public lighting	58.3	159.7	201.7	278.5	275.8	278.2	297.6	298.9	332.4
Traction	0.1	0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Agriculture	1570.9	4232.8	6064.6	8631.0	9128.3	9558.2	9971.1	10372.0	10762.2
Public water works	10.2	45.7	71.2	123.9	134.1	144.0	161.0	171.0	183.4
Miscellaneous	12.2	63.4	814.0	130.8	268.5	270.0	142.8	166.4	319.7
Total	**14664.9**	**32571.3**	**48468.9**	**69632.8**	**74187.5**	**77935.7**	**82312.2**	**86398.7**	**91022.3**
Connected load									
Domestic	5985.9	13078.6	21218.5	32051.2	38979.0	46183.0	49254.5	51589.7	55643.2
Commercial	1911.0	4494.0	6071.8	8340.8	8730.6	10701.7	11799.9	12123.0	12973.8
Industrial (low-and medium-tension)	4560.6	9934.0	17766.2	20477.2	23016.4	23736.0	24404.3	24592.9	25428.4
Industrial (high-tension)	6383.6	14909.8	16443.1	22469.5	23949.3	26184.1	28034.2	29642.2	31970.3
Public lighting	167.7	322.5	495.2	632.6	686.1	765.9	768.3	787.8	828.8
Traction	417.7	699.4	1020.4	1563.0	1672.6	2027.2	1981.2	2300.4	2147.5
Agriculture	6224.8	16489.2	22605.2	32511.5	34562.3	36399.9	38556.0	40108.3	42166.0
Public water works	269.7	696.6	1084.8	1680.4	2093.0	2236.7	2110.3	2108.3	2231.2
Miscellaneous	309.0	774.1	1241.3	1175.1	1975.5	1561.7	2034.0	2248.4	1951.3
Total	**26230.0**	**61398.2**	**87946.5**	**120901.3**	**135664.8**	**149796.2**	**158942.7**	**165501.0**	**175340.5**

Note

All figures pertain to 31 March of the respective years

Sources

1. CEA. 1995 Public Electricity Supply, All India Statistics, General Review, 1993/94. pp. 196–200 New Delhi: Central Electricity Authority 214 pp.
2. CEA. 1997 Public Electricity Supply, All India Statistics, General Review, 1995/96. pp 196–200. New Delhi Central Electricity Authority 214 pp

Table 33

Sale of power to consumer by category (MWh) 1998/99

State/electricity department	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industry*	*Railway traction*	*Outside states/ union territory*	*Others*	***Total***
State								
Andhra Pradesh	5496	1446	9834	9739	905	182	1322	**28924**
Assam	596	227	62	703	0	0	894	**2482**
Bihar	1210	482	1758	5120	575	89	268	**9502**
Delhi (DESU)	3460	534	96	3543	0	0	1844	**9477**
Gujarat	2947	823	13157	12802	449	0	3225	**33403**
Haryana	1808	296	3978	2022	111	445	489	**9149**
Himachal Pradesh	500	140	14	1258	0	738	424	**3074**
Jammu and Kashmir	690	143	505	375	0	0	1157	**2870**
Karnataka	3376	432	7651	3437	52	0	993	**15941**
Kerala	3283	946	383	622	0	0	3533	**8767**
Madhya Pradesh	4557	725	9206	6654	1315	170	1953	**24580**
Maharashtra	5690	1450	15965	18000	950	450	6645	**49150**
Meghalaya	95	48	2	72	0	180	119	**516**
Orissa	1813	413	275	4478	223	0	670	**7872**
Punjab	3613	764	6500	8032	0	513	393	**19815**
Rajasthan	2469	794	5062	6153	223	250	1246	**16197**
Tamil Nadu	4361	1884	7299	11069	396	197	1860	**27066**
Uttar Pradesh	8266	2367	10112	6865	915	407	1369	**30301**
West Bengal	2283	1038	1610	2774	546	21	1990	**10262**
Sub-total	**56513**	**14952**	**93469**	**103718**	**6660**	**3642**	**30394**	**309348**
Electricity department								**0**
Arunachal Pradesh	85	9	0	11	0	0	13	**118**
Goa	261	84	13	652	0	0	96	**1106**
Manipur	169	22	10	52	0	0	84	**337**
Mizoram	128	13	0	2	0	0	19	**162**
Nagaland	79	9	0	20	0	0	27	**135**
Pondicherry	156	54	116	689	0	0	26	**1041**
Sikkim	49	15	0	18	0	0	14	**96**
Tripura	113	24	79	45	0	0	81	**342**
Sub-total	**1040**	**230**	**218**	**1489**	**0**	**0**	**360**	**3337**
Grand total	**57553**	**15182**	**93687**	**105207**	**6660**	**3642**	**30754**	**312685**

DESU - Delhi Electricity Supply Undertaking

Source

Planning Commission 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments p. 71 New Delhi Power and Energy Division, Planning Commission, Government of India

Table 34

Plan expenditure and the share of power

Five-Year Plan	*Period*	*Plan expenditure (million rupees)* ‡	*Power (million rupees)*	*Total energy (million rupees)* *
First	1951–56	19600	0	3861 2 (19 7)
Second	1956–61	26700	2589.9 (9.7)	3310 8 (12.4) *
Third	1961–66	85800	12526 8 (14.6)	15873 0 (18 5)
Fourth	1969–74	157800	29350.8 (18.6)	33453.6 (21 2)
Fifth	1974–79	394300	73734.1 (18.7)	99363 6 (25 2)
Sixth	1980–85	1092900	182514 3 (16 7)	307104 9 (28 1)
Seventh	1985–90	2202200	383182 8 (17 4)	621020 4 (28 2)
Eighth	1992–97	4341000	798744 0 (18.4)	1150365 0 (36 5)
Ninth	1997–02	8750000	1242500(14 2)	2222500 0 (25 4)

Total energy includes power, coal, oil and gas, and new and renewable sources of energy
Outlay
Expenditure at current price at the base year of the respective plants

Note
Figures in parentheses denote percentages of total expenditure

Source
Planning Commission 1999 Ninth Five-Year Plan, 1997–2002 Volume II Thematic Issues and Sectoral Programmes New Delhi Planning Commission, Government of India

Table 35

List of private sector projects commissioned

Year	Name of the project
Private power projects	
1992/93	Shivpur HEP(18 MW) of Bhoruka Power Company, Karnataka
1994/95	Maniyar HEP (12 MW) of Carborandum Universal, Kerala
1995/96	Hazira CCGT (combined cycle gas turbine) (330 MW) of Essar Power Ltd, Gujarat
	1996/97
	Jegurupadu (2 x 45.8 + 48 MW) of GVK Industries, Andhra Pradesh
	Tawa HEP (13.5 MW) of Hindustan Electro Graphite Ltd, Madhya Pradesh
	Godavari CCGT (2 x 46 1 MW) of Spectrum Power, Andhra Pradesh
	Guntur Branch Canal-I HEP (3 75 MW)
	Vijjeswaram CCGT (112 MW) of APGPCL (Andhra Pradesh Power Gas Corporation Ltd)
	Jojobera TPP (thermal power plant) (67.5 MW) of Jamshedpur Power Company, Bihar
	1997/98
	Jegurupadu (75 5 MW) of GVK Industries, Andhra Pradesh
	Baroda (167 MW) CCGT of GIPCL (Gujarat Industries Power Company Ltd
	Hazira CCGT (185 MW) of Essar Power Ltd, Gujarat
	Vijjeswaram CCGT (60 MW) of APGPCL
	Godavari (CCGT (46 1 + 69 MW) of APGPCL
	Adamtilla GBPP (9 MW) of DLF Power Co Ltd
	Bansakandi GBPP (105 MW) of DLF Power Co Ltd
	Paguthan CCGT (138 x 3 MW) of Gujarat Torrent, Gujarat
	1998/99
	Banskandi GBPP (5 MW) of DLF Power Co Ltd
	Gurgaon CCGT (25 MW) of Magnum Power Generation Ltd
	Paguthan CCGT (241 MW) of Gujarat Torrent, Gujarat
	Dabhol CCGT (740 MW) of Enron, Maharashtra
	Basin Bridge DGPP (200 MW) of GMR Vasavi, Tamil Nadu
Licensees	
1992/93	New Southern Gen Station (135 MW) of CESC (Calcutta Electric Supply Company Ltd)
1993/94	Trombay (120 MW GT-U-I TPP of BSES, (Bombay Suburban Electric Supply), Maharashtra
1994/95	Dahanu (2 x 250 MW) TPP of BSES, Maharashtra
	Trombay (60 MW ST/U-2) TPP of BSES, Maharashtra
1995/96	Bhira PSS (150 MW) of Tata Electric Company, Maharashtra

Source
MoP 1999 New Delhi Ministry of Power

OVER THE YEARS WE HAVE LANDMARKED INDIA WITH MANY NATIONAL MONUMENTS

Each coal and gas-based power project of NTPC is
a national monument. Each a
hallmark of our unparalleled contribution to
India's power scenario which makes NTPC the
largest power generating enterprise with an installed
capacity of 17,878 MW.

The Corporation also manages two
power stations having a total generating
capacity of 975 MW.

With an additional 2260 MW of
generating capacity under various stages of
completion, NTPC is steadily moving towards being a
30,000 MW Corporation by 2007 A.D.

NTPC is all set to landmark India
with many more national monuments.

एनटीपीसी
NTPC

**National Thermal Power
Corporation Ltd.**

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Leading by Vision

Renewable energy sources and technologies

Introduction

The threat posed to sustainability by GHG (greenhouse gas) emissions and natural resource base deterioration has caused worldwide concern. The natural resource base has deteriorated considerably due to the rapid growth in population, urbanization, and fossil fuel consumption. The objectives of natural resource conservation and environmental protection need to be integrated with the overall developmental process, as articulated in Agenda 21 of the United Nations Conference on Environment and Development.

Two important strategies need to be adopted in parallel for the conservation of the natural resource base. The first strategy pertains to the appropriate pricing of exhaustible or non-renewable resources by moving away from the APM (administered pricing mechanism). The APM does not reflect the true cost and tends to under-price resources quite significantly. Moving towards the true costs would encourage fuel efficiency and prevent wasteful energy use.

The second strategy, which is discussed in this chapter, is that of developing and promoting appropriate technologies using renewable natural resources such as biomass, water, wind, and solar energy. Recourse to renewable sources of energy has become imperative with the growing climate change concerns and the dwindling fossil fuel reserves. Though the developed nations have contributed the most to global warming, the contribution of developing countries is also increasing at an alarming rate. In India, electric power generation is the largest source of GHG emissions and accounts for 48% of the carbon emitted. The RETs (renewable energy technologies), thus, have a vast potential for energy generation and are environmentally sustainable (Table I).

Table I Estimated potential for renewable energy technologies in India

Sources/systems	*Approximate potential*
Biogas plants (no.)	12 million
Improved woodstoves (no.)	120 million
Biomass	17000 MW
Solar energy	20 MW/km^2
Wind energy	20000 MW
Small hydro power	10000 MW
Ocean energy	50000 MW
Energy from urban, muncipal, and industrial wastes	1700 MW

Source MNES (1999)

Recognizing the importance of the renewable sources of energy, CASE (Commission for Additional Sources of Energy) was set up in 1981. Subsequently, in 1982, the Department for Non-conventional Energy Sources was created, which was later, upgraded to the MNES (Ministry of Non-conventional Energy Sources) in 1992.

IREDA (Indian Renewable Energy Development Agency Limited) was established in March 1987 as a public sector enterprise for the promotion, development, and financing of NRSE (new and renewable sources of energy) technologies. As on 31 December 1998, the cumulative sanctions by IREDA amounted to 23.79 billion rupees and the disbursements were 99.03 billion rupees. Concomitantly, this was accompanied by financial and technical assistance from the World Bank, the UNDP (United Nations Development Programme), the GEF (Global Environment Facility), and the Asian Development Bank.

The MNES has allocated 10% of its budgetary support for the development of north-eastern states, including Sikkim. It has also included different plans in its various programmes to enhance the role of women, both as a beneficiary and a contributor.

About 1050 MW of power generating capacity, constituting approximately seven per cent of the total power capacity addition, was contributed by non-conventional energy sources during the Eighth Five-Year Plan. The Eighth Plan laid emphasis on the operational programmes of biogas, low-grade solar thermal devices, improved *chulhas* and other sources for meeting the energy needs, especially of the rural areas. The achievements made by the renewable energy programme during the Eighth Plan period are given in Table 1.

The applications of various renewable energy technologies are discussed below.

Power generation

Bagasse-based cogeneration

The sugar industry that generates bagasse as biomass waste, has been targeted for bagasse-based cogeneration as it offers a vast potential and is well organized. It has been estimated that nearly 3500 MW of power can be generated from this industry, if the existing 430 sugar mills adopt modern techniques of cogeneration. The total installed capacity, as on 31 March 1998, was 82 MW. The potential of each state for bagasse-based cogeneration is given in Table 6. The major constraints in setting up cogeneration projects are (1) high capital investment; (2) lack of proper policies in respect of wheeling, banking, and buy-back of power generated by the cogenerating industries; and (3) non-remunerative payment against the power exported by the cogenerators (Planning Commission 1997).

The MNES provides subsidies on the equipment cost for projects using state-of-the-art technology and soft loans for the modernization of projects using relatively established technologies. The state governments provide various fiscal and financial incentives for bagasse-based cogeneration. The Programme Partnership Initiative was launched in 1998 to motivate, assist, and encourage sugar mills to take up cogeneration. The installed capacity of different states for biomass power projects is given in Table 9. The Ninth Plan focus is on the promotion of this industry by (1) launching demonstration programmes in cooperative/private sugar industries, (2) providing interest subsidy in the form of soft loans at a low rate of interest, and (3) providing necessary financial and technical support for the preparation of DPRs (detailed project reports).

Biomass gasifiers

Unlike other forms of renewable energy such as solar and wind, chemical energy is stored in biomass (for example, in coal or oil), which can be released on demand. Hence, storage costs, such as those for a battery, can be reduced drastically. Also, biomass-based power plants are ideal for decentralized applications in rural areas, where it is either costly to extend the grid or the power demand is low.

Agro-processing industries such as cigarette factories, cashew-processing units, and ayurvedic medicine manufacturing units produce large quantities of biomass. The viability of gasifier power plants is strongly linked with the supply mechanisms of biomass. It has been estimated that the area required for biomass-based power generation is of the order of 0.03×10^6 kWh/ha a year.[1]

In many states of India, on account of the poor quality of the grid and its reliability, the industries are forced to switch over to their own captive power generation using diesel. Considering the relatively stable and low price of biomass, it makes good sense to couple these gensets with gasifiers. Dual-fuel (gasifier and diesel) operating electric power generators, thus, offer a great potential for fuel saving and decentralized power generation.

Over a thousand wood gasifiers with a generating capacity of 14 MW have been installed till 1998. A 0.5-MW grid-connected gasifier-based R&D-cum-demonstration project using wood from specially raised captive energy plantations in Gujarat was commissioned in 1997. The distribution of gasifiers in each state is given in Table 21.

Biomass combustion

Three major BCPPs (biomass combustion-based power projects) have been implemented by the MNES. Of these, the 6-MW prosopis-based project in Andhra Pradesh (commissioned in June 1999) and the 5-MW rice-husk-based project in Madhya Pradesh (commissioned in August 1999) received a capital subsidy from the MNES. The third 12-MW private sector project in Tamil Nadu using cane trash and bagasse as fuel was supported by IREDA.

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[1] assuming a plant load factor of 60%, biomass consumption of 1.2 kg/kWh, and a biomass yield of 35 tonnes/hectare a year.

The BCPPs are set up on a build-own-operate basis, by inviting proposals from prospective promoters/investors in the private sector.

As an incentive to promoters, a one-time subsidy of up to 30% of the project cost is provided by the MNES, subject to the fulfilment of certain eligibility criteria. During 1994–97, 18 BCPPs with a total capacity of 69 MW, which supply power to the grid, were installed in five states and 17 projects aggregating 97 MW are under implementation in seven states. Over 100 million units of electricity have been fed to the state grids so far from these projects. After commissioning the above-mentioned capacity, more than 800 million units will be fed to the grids every year saving 0.5 MT (million tonnes) of coal and reducing 1 MT of carbon dioxide emissions into the atmosphere.

Solar photovoltaic systems

The SPV (solar photovoltaic) technology enables the conversion of sunlight into electricity in an environmentally friendly manner. The PV (photovoltaic) systems have emerged as useful power sources for applications such as lighting, water pumping, telecommunications, and power plants for meeting the requirements of villages, hospitals, lodges, etc. As per the reports received from the state implementing agencies, 15 206 home-lighting systems, 20 484 solar lanterns, 437 streetlighting systems were installed during 1997/98. The installation of SPV systems in each state is given in Table 10.

The solar power programme involves the development of grid-interactive SPV systems. In 1995, the MNES launched a scheme to augment and supplement grid power by installing PV power projects in the range of 25–100 kW for rooftop systems on public buildings to demonstrate peak load saving applications in major urban areas and for transmission and distribution support systems in remote rural areas. Under the scheme, a subsidy of two-thirds of the total project cost was provided to the SEBs (state electricity boards), state nodal agencies, and private utilities, subject to a maximum of 20 million rupees per 100 kW capacity. With a view to expanding the market for PV technologies for meeting the energy needs in developing countries, the World Bank has initiated a programme on PV market transformation initiative.

Wind energy systems

India has made a mark in the wind energy sector and now ranks fourth in the world in wind power installations. The wind power programme has achieved near commercialization stage due to the initiatives taken by the MNES. The various fiscal and promotional incentives introduced by the MNES have encouraged participation from the private sector. The Ninth Plan provides a further boost to these incentives and also withdraws some concessions, such as accelerated depreciation (Planning Commission 1997). The installed wind power capacity rose from 40 MW at the beginning of the Eighth Plan to 992 MW in December 1998. The potential of windfarms in selected states/districts is provided in Table 11. While the private sector projects have gained momentum in Andhra Pradesh, Gujarat, and Tamil Nadu, some wind power activities have also been initiated in other states with potential such as Karnataka, Maharashtra, and Madhya Pradesh.

The private sector can avail of soft loans and short-term finances from IREDA.

The International Development Agency has extended a credit worth 78 million dollars to the private sector for the development of windfarms. This line of credit also includes 31 million dollars in the form of grants from the GEF due to the environmental benefits that accrue through the installation of windfarms. Besides, financial institutions such as IDBI (Industrial Development Bank of India), IFCI (Industrial Finance Corporation of India), ICICI and power finance companies like PFC (Power Finance Corporation) extend financial support to wind power projects. In future, the guidelines for wheeling, banking, third-party sales, and buy-back of power generated by windfarms would be strengthened through a suitable regulatory mechanism. The demonstration programmes would be kept at a minimum during the Ninth Plan and surveys would be conducted to identify the potential sites for the development of windfarms. C-WET (Centre for Wind Energy Technology) has been set up in Chennai for certification, testing, standardization, training, and information dissemination of RETs.

Small hydro power

The total potential for small SHP (small hydro power) (up to 3 MW) in India has been estimated at about 10 000 MW. The installed capacity as on 31 March 1998 was 155.38 MW. The scheme for the development of SHP provides for 100% financial support up to 150 000 rupees for survey and investigation and 50% support up to 100 000 rupees for

DPR preparation. Besides, it also provides capital subsidy for government-owned demonstration projects, interest support for commercial projects, and support for modernization and renovation of old hydel projects. However, the inadequate state plan allocation, lack of coordination among the agencies, slow clearance/allotment of the private sector projects, low priority by the SEBs, lack of clear-cut policy for private sector participation, and the absence of identified sites have acted as deterrents in the promotion of this programme. The status of installations in each state up to 3 MW is given in Table 15.

Energy from urban and industrial wastes

Waste management technologies have now assumed relevance and importance in India. As shown in Table I, nearly 1000 MW can be generated from urban and municipal wastes and about 700 MW from industrial wastes. Though the achievements in the previous plans have not been significant, efforts are being made to generate energy from wastes through a major thrust on R&D. To speed up the various programmes, the National Bioenergy Board has been set up for evolving policy guidance and direction. The MNES, assisted by the UNDP/GEF, is developing biomethanation project as means of reducing GHG emissions. A number of state governments and state agencies have initiated projects for energy recovery from rural and industrial wastes. Projects based on conversion technologies, namely biomethanation, pelletization, gasification, pyrolysis, incineration, and sanitary landfills are being developed with the support of the MNES. However, there is a need to launch more demonstration projects. Also, private sector participation can be encouraged by providing adequate financial and fiscal incentives as well as by defining necessary legislation, wherever required, for waste disposal, etc. A capacity addition of 50 MW from urban and industrial wastes has been set during the Ninth Plan.

Thermal applications

Biogas plants

The National Project on Biogas Development was started in 1981/82 for the promotion of family-type biogas plants. The project aims at providing a clean and inexpensive energy source, producing enriched manure, improving sanitation, and elevating the status of women in rural areas. Against a target of setting up nearly 133 000 family-type biogas plants in 1998/99, about 54 250 plants were installed during April–December 1998. Table 20 gives the details of family-type biogas plants in each state. The Ninth Plan has set a target of installing at least 1.2 million family-type biogas plants.

Biomass gasifiers for thermal applications

The techno-economic feasibility of utilizing biomass gasifiers for a variety of thermal applications has been well established now. The capacity rating of these gasifiers is up to 150 kg of biomass per hour (equivalent to 400 000 kcal). The lower capacity gasifiers are used in small-scale industries like silk reeling, textile dyeing, drying, and in community cooking. The bigger-sized gasifiers can be used in industrial applications, such as production of carbon dioxide and magnesium chloride. Moreover, there is a demand for large gasifiers in industries like cement, sugar, and calcium chloride for meeting the process heat requirement. Their applications in limekilns, brick kilns, mini cement plants, in the manufacture of plaster of Paris, etc., seem to be promising, but it is yet to be explored systematically. Experience so far has shown that biomass gasifiers for thermal applications have inherently low payback periods. Moreover, the use of gasifiers offers substantial reductions in fuel consumption and harmful emissions.

Improved cookstoves

The National Programme on Improved Chulhas was launched in 1984/85 with the objectives of fuel conservation, reduction of smoke, conservation of forests and the environment, providing employment, and elevating the status of women and children in rural areas. Improved *chulhas* have a thermal efficiency of 20%–35% as compared to the traditional *chulhas*, which have an efficiency of 10%. In addition, the improved *chulhas* are estimated to save about 11 MT of fuelwood equivalent every year. The total number of improved *chulhas*, as on 31 March 1998, was 28.5 million. The details installations in each state are provided in Table 24. However, an evaluation study by the NCAER (National Council for Applied Economic Research), for the period 1992–95, revealed that (1) nearly one-fourth of the *chulhas* installed stopped functioning within a year of their installation, (2) the maintenance of *chulhas* by beneficiaries was poor, and (3) the number of self-employed workers and their competence was short of the requirements. The pattern of subsidies for the promotion of improved chulhas has been further rationalized to encourage market support.

Solar thermal technologies

The following section discusses the utilization of solar thermal energy for various end-uses.

Solar water heating systems

In India, solar thermal systems are used for domestic and industrial applications. In the industrial sector, solar thermal energy is utilized for pre-heating boiler feed water and for supplying direct process heat. The resultant savings are mainly in terms of boiler fuel. In the domestic sector, since solar water heating systems primarily replace electric geysers, they not only save electrical energy, but also contribute to reduction in the peak load demand. Besides, they also prevent carbon dioxide emissions into the atmosphere. The small capacity systems (up to 2000 litres per day) work on natural circulation or thermosyphon principle. However, for larger capacity systems, pumps with necessary controls are required for the circulation of water and such systems are designated as forced flow systems. The distribution of solar thermal systems in each state is given in Table 25. According to a conservative estimate, the potential for the deployment of solar water heaters is around 30 million square metres of collector area, of which 450 000 square metres of collectors have already been installed. Approximately, 1000 solar domestic water heaters (2000 square metres of collector area) can contribute to a peak load shaving of 1 MW.

Looking at the vast potential and resource availability, the government, through the MNES, initially provided various incentives in terms of subsidies and other fiscal benefits for the promotion of solar water heating systems. But, capital subsidies were abolished in July 1993 when these technologies attained a certain level of commercialization. Instead, provisions were made for soft loans through IREDA and other designated banks.

Solar energy for industrial applications

A major portion of thermal energy requirements in the Indian industrial sector lies in the temperature range of 100 °C to 250 °C, which corresponds to the medium temperature range of solar thermal systems. This is supplied either as high-temperature pressurized water or as low-pressure steam. These medium temperature requirements are met primarily by the combustion of fossil fuels like coal, lignite, and furnace oil. There are 22 major industries where boilers supply process heat either in the form of steam or hot air up to a temperature of 150 °C. These industries include dairy, food processing, textiles, hotel, edible oil, chemical, marine chemicals, bulk drug, breweries, and distilleries.

Solar thermal systems could be employed to meet this demand in a complementary role. It is estimated that about 60% of thermal energy consumed in industry is used for the processing of end products. Even if only 10% of this requirement is met through solar thermal systems, this will lead to savings of about 292 400 kilolitre of furnace oil a year and reduction in the resultant carbon dioxide.

Solar cooking

In the household sector, the bulk of the energy is spent in cooking. In recent years, there has been a gradual shift from fuelwood to liquefied petroleum gas for cooking. According to a survey conducted by the NCAER in 1978/79, 85.2% of the total energy consumption in the household sector was accounted for by cooking. Therefore, cooking with solar energy appears to be a viable option in the domestic sector. At the micro level, solar cookers facilitate financial savings for the consumer; at the macro level, they help in the conservation of natural gas and fuelwood. Of the many types of solar cookers (concentrating-dish, indirect heating, with or without heat storage, hybrid, etc.), only the box-type solar cookers have reached the commercialization stage. Nearly 5000 solar cookers were installed during 1997/98 and about 462 000 cookers have been sold since the inception of the MNES. In April 1994, the subsidy provided by the MNES on solar cookers was replaced by financial support for promotional activities such as publicity, cooking demonstrations and competitions, training, development of marketing network, etc. In 1998, a programme was envisaged for setting up solar food restaurants by state nodal agencies in big cities.

Solar thermal power generation

Out of the various energy uses or sources contributing to the global greenhouse effect, energy-related carbon dioxide emissions are the largest single source, with power plants contributing about 11% of the carbon dioxide emissions. In this scenario, to mitigate the greenhouse effect, the introduction of more costly, but cleaner energy technologies, such as solar thermal power generation, is imperative.

For electricity generation through solar thermal route, the following technologies are feasible (1) parabolic dish, (2) parabolic trough, (3) central receiver, (4) solar pond, and (5) solar chimney. Out of these, line-focusing parabolic trough technology is commercially available. The 354-MW capacity plants in California, based on LUZ parabolic trough technology, continue to operate although no further development has taken place there on account of financial problems. Despite this setback, the plants mark a major step forward in the commercialization of solar thermal power by bringing down the power cost from $0.24/kWh in 1984 to $0.08/kWh in 1989 though various technological and operational innovations. The SolarPACES programme indicates that the levelled electricity cost of solar thermal power plants can be reduced with increased size to around $0.13/kWh for state-of-the-art 100-MW technologies and to a range of $0.08–0.11/kWh for future 100-MW commercial developments.

The EC (European Community) is focusing on a strategy to develop these technologies and reduce costs so that market forces alone will support the industry by 2010. The world market is predicted to be 5.1 GW a year during the period 2010 to 2015, including 800 MW a year potential for India.

Apart from grid-connected centralized power plants, solar thermal power generation plants could also operate in stand-alone mode in decentralized applications like rural electrification and in remote locations like islands. It is estimated that if the cost of extending the grid to the remote location is also taken into account, solar thermal power from parabolic dish is more viable than grid power. In centralized mode, parabolic trough-natural gas hybrid systems with 25% solar share appear to be most competitive.

In India, a major initiative in solar thermal power generation has been taken in the form of 140-MW integrated solar combined cycle power project in Mathania, near Jodhpur. It comprises 35-MW solar component based on LUZ type III parabolic trough collectors and 105-MW conventional power component. The RSPCL (Rajasthan State Power Corporation Limited), created especially for this, would implement it.

Solar ponds

Salt-gradient solar ponds (low-cost solar collectors with integral storage) are both appropriate and relevant in the Indian context. In India, though solar pond research dates back to 1971, none of these ponds were connected to any end-use. Moreover, the construction and operation of a large-sized solar pond (the largest solar pond so far was of 1600 square metres) was not tried out. The 6000 square metre, Bhuj solar pond at the Kachch Dairy, Bhuj, was conceived as an R&D project to demonstrate the feasibility of using a salt-gradient solar pond to deliver industrial process heat. The construction of this pond was started in 1987 as a collaborative effort among Gujarat Energy Development Agency, Gujarat Dairy Development Corporation Limited, and TERI. In fact, the Bhuj solar pond is a major technology development effort undertaken jointly by a state energy promotion agency, a user industry, and a research institution. The Bhuj solar pond started supplying hot water to the dairy in September 1993, saving about 935 MT of lignite a year, at full capacity utilization of the solar pond.

The economic viability of a salinity-gradient solar pond is governed by factors such as its size, proximity to sources of inexpensive salt/bittern and water, and land availability. The following niche areas have been identified after careful matching of these requirements with the deliverables: (1) process heating, (2) water desalination, (3) refrigeration, (4) production of magnesium chloride, (5) bromine recovery from the bittern, and (6) enhancement of the salt yield in the salt farms, etc.

Solar air-heating systems and solar architecture

Apart from heating and cooking, solar energy is also being used for drying farm produce, which minimizes the post-harvest loss caused by open sun drying. The partial energy delivery unit, with 2500 square metres of collector area, has been installed in southern parts of India for pre-heating the air for drying tea, spices, etc.

The benefit of solar energy is also being taken in the form of solar passive architecture while designing energy-efficient buildings. This minimizes the use of conventional fuels and electricity. A programme comprising training and education, demonstration, and publicity has been implemented by the MNES to promote solar-based building designs. Under the Solar Buildings Programme, two buildings have already been constructed in Himachal Pradesh and many more are on the verge of completion in other parts of the country.

New technologies

Chemical sources of energy

Currently, four types of fuel-cell technologies, namely, phosphoric acid, polymer electrolyte, solid oxide, and molten carbonate fuel cells, are receiving attention for commercialization. However, the high initial costs and the unproven long-term performance are the main deterrents for their widespread application for generating electricity and heat.

Ocean energy

Ocean thermal energy, tidal energy, ocean winds, and wave energy are the various forms of ocean energy which are receiving attention. However, with the present status of technology, only tidal energy can be harnessed. It has been estimated that the total potential of ocean energy is approximately 50 000 MW. A few potential sites have been identified for tidal power development at the Gulf of Kachch and Gulf of Khambat in Gujarat and in the Sunderbans Delta in West Bengal.

Geothermal energy

Geothermal energy, which is derived from the high-temperature geothermal fluids, can be utilized for power generation and thermal applications like greenhouse cultivation, space heating, power generation and cooking. So far, projects on an experimental basis for the cultivation of mushrooms and poultry farming have been implemented in Ladakh. Out of 300 geothermal spring locations in the country, only those in Jammu and Kashmir and Madhya Pradesh can be used for power generation, while the other fields can be used for non-electrical applications. Proper utilization of geothermal energy requires adequate infrastructure and training facilities.

Alternative fuels for surface transport

Hydrogen is a clean energy carrier with a high heat content, which can be produced by the electrolysis of water using solar energy. Hydrogen can be used in the transport sector to substitute petroleum products.

The MNES is promoting the substitution of petrol-driven vehicles by BOVs (battery-operated vehicles) and diesel-run vehicles by alcohols like ethanol and methanol. To facilitate the implementation of BOVs and alcohol-operated vehicles, CASE offers subsidies and has approved the operation of the state road transport corporation buses on dual-fuel mode, namely diesel–alcohol, in five states. However, the use of BOVs has been constrained by inadequate infrastructure support for charging/replacement of batteries, poor performance, high maintenance cost, failure of components, etc. Thus, initiatives have been taken by the ministry to develop batteries with high energy and power density, longer life cycle, and free maintenance, and are less polluting. Efforts are being taken to develop and commercialize advanced lead–acid, nickel–metal hydride, and nickel–iron and lithium batteries.

Future outlook

India is well endowed with substantial renewable energy sources. However, the exploitable potential depends upon the availability of resources, the status of technology, and the end-use patterns.

The application of RETs is largely influenced by the degree of R&D, development of appropriate products (based on consumer needs) as well as their commercialization. Enhanced international cooperative activities aimed at sharing technological expertise, promoting scientific research, and mobilizing financial resources could also contribute immensely to the development of RETs. Limited resources are a serious constraint and, therefore, the MNES has adopted a strategy whereby projects jointly implemented by the industry/institutions are given a priority.

Widespread information dissemination and awareness campaigns need to be launched to apprise people of the benefits of RETs and their advantages over other technologies. RETs have relied heavily on central subsidies provided either directly through IREDA or through centrally-sponsored schemes. The need, therefore, is to shift from capital subsidies to interest subsidies and gradually move towards private entrepreneurship and community participation by phasing out subsidies. Suitable legislation and policy, along with a necessary regulatory mechanism, have to be evolved for promoting these technologies.

If all the RETs were to be successfully adopted, it is estimated that the annualized system energy cost would change from 4114 billion rupees to 4019 billion rupees. In addition, the carbon dioxide emissions would go down by 20% over the business-as-usual scenario and, the emission of suspended particulate matter would be reduced by 24%.

References

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Planning Commission. 1997
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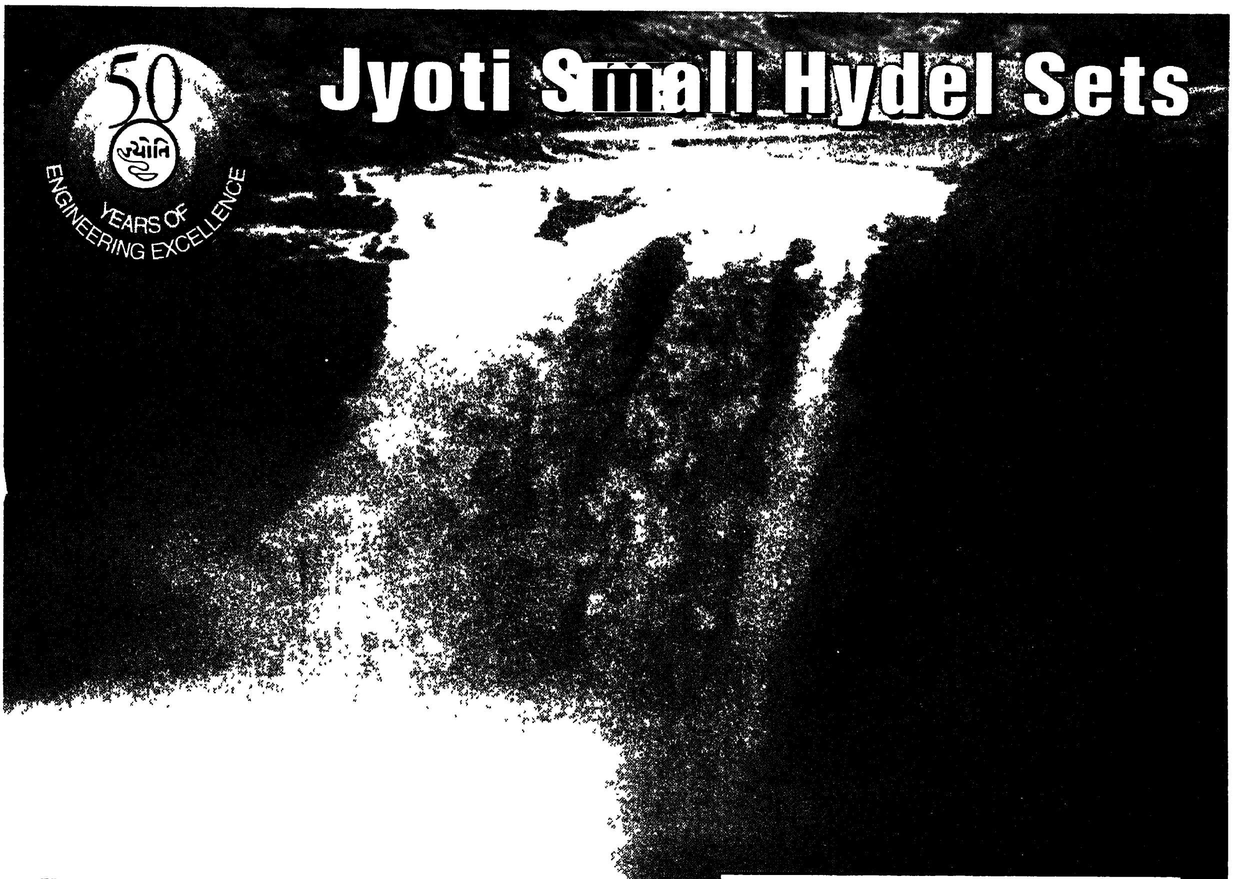
New Delhi: Planning Commission, Government of India.

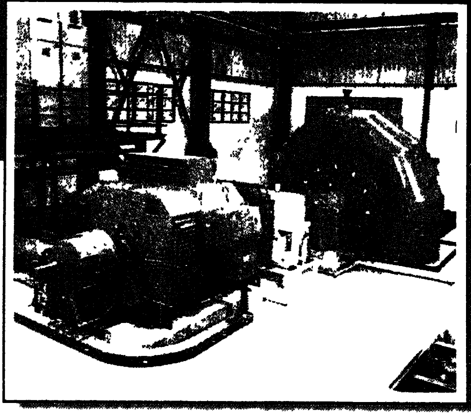
50 YEARS OF ENGINEERING EXCELLENCE

Jyoti Small Hydel Sets



Dispelling Darkness and Bringing Light to Millions

- Product Range: 5 kW to 10,000 kW
- Hyro-Electric Generating Set consisting of Turbine (Francis, Pelton, Turgo-Impulse, Propeller, Kaplan, Semi-Kaplan or Tubular), electronic or Hydro-mechanical Governor, Butterfly or Spherical Valve, Generator, Control Panels, etc
- Jyoti is one of the very few to assume single source responsibility of designing, manufacturing, erecting and commissioning complete Hydro Generating set
- Till now, Jyoti has supplied more than 450 hydel sets with total installed capacity of 1,40,000 kW
- More than 60 'Jyoti' Hydel Sets working in countries like Nepal, Bhutan, New Zealand, Afghanistan, Malaysia, Papua New Guiena, Ghana, USA etc
- The first unmanned Small Hydro Power Station in India 2 X 1600 kW, fully automatic (single push button start) and remote controlled from a distance of 2 Kms was designed, manufactured and commissioned by Jyoti at Bhivpuri Tail Race Power House of Tata Electric Companies in 1997
- One of the world's highest altitude power stations at 3900 metre having installed capacity of 200 kW at RONGTONG in Himachal Pradesh was designed, manufactured and commissioned by Jyoti Ltd in 1984
- In year 1997, Jyoti received award for outstanding contribution to the development of Small Hydro Power in India, as a equipment manufacturer from International Association for Small Hydro (IASH)



The First unmanned small Hydro Power Station in India- 2X 1600 kW, fully automatic and remote controlled at Bhivpuri, Maharashtra

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Hydel Systems Division
Industrial Area, Vadodara 390 003, INDIA
Phone 380633-627, 381402
Fax 0091-265-381871 / 380538
E-mail hyd jyoti@sm3 sprintrpg.ems vsnl net.in
Website http //www jyoti com

Table 1

Target achievements of renewable energy in the Eighth Five-Year Plan period

Category	Eighth Plan target		1992/93	1993/94	1994/95	1995/96	1995/96	1996/97
	Approved	Revised	Actual	Actual	Actual	Target	Actual	Target
Biogas								
Family type (million)	0.75	1	0.19	0.22	0.20	0.16	0.18	0.18
CBP/IBP (number)	450.00	—	189.00	215.00	236.00	200.00	35.30	250.00
Improved chulha (million)	10.00	18	1.98	2.43	2.67	2.40	2.95	2.70
IREP (blocks)	500.00	—	86.00	100.00	100.00	—	108.00	100.00
Solar thermal								
Solar thermal system (m²)	275000.00	—	24595.00	40866.00	35000.00	35000.00	50000.00	35000.00
Solar cookers (million)	0.30	—	0.05	0.05	0.03	0.03	0.04	0.03
SPV (solar photovoltaic)								
Power units (kWp)	1720.00	—	143.66	122.00	100.00	30.00	89.00	50.00
Community lights (number)	—	—	—	—	—	—	—	—
Domestic lights (number)	25000.00	—	3043.00	6399.00	500.00	1000.00	—	—
SPV lanterns (number)	—	—						
SPV streetlights (number)	—	—						
SPV water pumps (number)	600.00	—	106.00	1894.00	1000.00	—	738.00	1000.00
Wind								
Wind power (MW)	100.00	500	12.68	61.09	235.00	10.00	382.11	100.00
Wind pumps (number)	4000.00	—	93.00	41.00	200.00	200.00	29.00	200.00
Wind battery chargers (number)	500.00	—	4.00	6.00	15.00	35.00	1.00	35.00
Urjagram (number)	—	—	29.00	25.00	25.00	—	—	—
Biomass stand-alone gasifiers (MW)	—	—	2.00	4.00	5.00	6.00	4.40	6.00
Urban/agricultural waste								
Bio-energy	—	—	—	—	—	—	—	—
Biomass cogeneration (MW)	—	—	—	—	—	—	—	—
Biomass combustion (MW)	300.00	800	—	—	4.00	50.00	37.00	55.00
Biomass gasifier (MW)	—	—	—	—	—	—	—	—
Micro hydel (MW)	200.00	600	12.02	5.35	25.00	35.00	7.50	30.00

CBP/IBP - community biogas plants/institutional biogas plants, IREP - Integrated Rural Energy Planning

Source

GoI. 1997 Annual Plan 1996/97. New Delhi Planning Commission, Government of India

Table 2

IREP (Integrated Rural Energy Planning): comparative statistics on select indicators for the different states: 1992/93

State	Achievement as % of targets	Average number of devices installed per block	Average number of types of devices installed	Number of types installed as % of number planned	Average number of devices installed per 1000 population
Gujarat	24.6	131.0	4.6	57.1	—
Haryana	78.8	2126.0	9.0	80.8	18.4
Himachal Pradesh	104.6	1441.0	7.1	96.8	22.5
Meghalaya	83.2	607.0	3.5	87.5	22.4
Uttar Pradesh	100.0	1291.0	6.1	100.0	9.5
West Bengal	—	979.0	4.6	—	5.7

Source

NCAER. 1996. Impact assessment of IREP: Final Report, January 1996. New Delhi: National Council of Applied Economic Research

Table 3

All-India potential availability (million tonnes) of agriculture-based biomass 1980/81 to 1995/96

Biomass	1980/81	1985/86	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
Rice husk	26.8	31.9	37.1	37.3	36.5	40.2	40.9	39.8
Wheat straw	48.4	62.7	73.5	74.3	76.3	79.6	87.5	83.3
Maize cobs	2.1	2.0	2.7	2.4	3.0	2.9	2.7	2.8
Pearl millet straw	8.9	6.1	11.4	7.8	14.8	8.3	12.0	9
Sugarcane bagasse	51.4	56.9	80.4	84.7	76.0	75.8	90.9	93.4
Coconut shell	0.8	0.9	1.3	1.4	1.5	1.6	1.8	1.9
Coconut fibre	0.9	1.1	1.6	1.7	1.9	2.0	2.2	2.3
Coconut pith	1.4	1.7	2.4	2.5	2.8	2.9	3.3	3.4
Groundnut shell	1.7	1.7	2.5	2.4	2.9	2.6	2.7	2.6
Cotton stalks	23.5	22.6	22.3	23.0	22.6	22.0	23.7	27.3
Jute sticks	3.9	4.5	3.1	3.3	2.8	2.7	2.7	2.7

Note

The conversion factors used are listed below

Rice husk = yield of clean rice x 0.5
Wheat straw = grain yield x 1.33
Maize cobs = grain yield x 0.3
Straw from pearl millet = grain yield x 1.66
Bagasse = weight of cane x 0.33
coconut: one nut = 135 g shell, 164 g fibre, and 246 g pith
groundnut shell = kernel yield x 0.33
cotton stacks = 3 tonnes/hectare
jute sticks = 3 tonnes/hectare

Sources

1. MoA. 1999. Agricultural Statistics at a Glance, March 1997. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture
2. Vimal O P, Tyagi and P D (eds). 1984. Energy from Biomass. New Delhi: Agricol Publishing Company. 440 pp
3. TERI. 1987. Potential for Renewable Energy Utilization in Andaman and Nicobar and Lakshadweep Islands. Submitted to the Department of Non-conventional Energy Sources, Government of India. New Delhi: Tata Energy Research Institute. 183 pp

Table 4

Potential availability (million tonnes) of agriculture-based biomass in different states: 1993/94

State	*Rice husk*	*Wheat straw*	*Maize cobs*	*Pearl millet (bajra) straw*	*Sugarcane bagasse*	*Coconut*			*Groundnut shell*	*Cotton stalks*	*Jute sticks*
						Shell	*Fibre*	*Pith*			
Andhra Pradesh	4.3	—	0.3	0.2	4.5	0.2	0.2	0.3	0.8	2.2	0.2
Assam	1.7	—	—	—	0.5	—	—	—	—	—	0.2
Bihar	3.0	5.8	0.5	—	1.5	—	—	—	—	—	0.4
Gujarat	0.4	1.2	0.1	1.3	3.4	—	—	—	0.2	3.4	—
Haryana	1.0	9.6	—	0.6	2.1	—	—	—	—	1.7	—
Himachal Pradesh	—	0.6	0.2	—	—	—	—	—	—	—	—
Jammu and Kashmir	0.3	0.5	0.2	—	—	—	—	—	—	—	—
Karnataka	1.6	—	0.3	0.3	7.0	0.2	0.2	0.3	0.4	1.7	—
Kerala	0.5	—	—	—	—	0.8	0.9	1.4	—	—	—
Madhya Pradesh	2.9	8.2	0.4	0.2	0.6	—	—	—	0.1	1.4	—
Maharashtra	1.2	1.4	0.1	2.0	9.3	—	—	—	0.3	7.4	0.1
Meghalaya	—	—	—	—	—	—	—	—	—	—	0.0
Orissa	3.3	—	0.0	—	0.3	0.0	0.0	0.1	0.0	—	0.2
Punjab	3.8	17.8	0.1	—	1.6	—	—	—	—	1.7	—
Rajasthan	—	4.6	0.3	1.7	0.3	—	—	—	0.1	1.6	—
Tamil Nadu	3.3	—	—	0.6	9.2	0.4	0.5	0.8	0.6	0.8	—
Tripura	—	—	—	—	—	—	—	—	—	—	0.0
Uttar Pradesh	5.1	27.7	0.4	1.5	35.0	—	—	—	0.0	—	—
West Bengal	5.7	0.8	0.1	—	0.2	0.0	0.1	0.1	—	—	1.4

Sources

1 MoA. Agricultural Statistics at a Glance (various issues). New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.
2 Vimal O P and Tyagi P D (eds). 1984. Energy from Biomass. New Delhi: Agricol Publishing Company. 440 pp.
3 TERI. 1987. Potential for Renewable Energy Utilization in Andaman and Nicobar and Lakshadweep Islands. Report submitted to the Department of Non-conventional Energy Sources, Government of India. New Delhi: Tata Energy Research Institute. 183 pp.

Table 5

Biomass power potential (MW)

Source	*Potential*
From surplus biomass	16000
From bagasse-based cogeneration in the existing sugar mills	3500
Total	**19500**

Source

MNES. 1999. Annual Report. New Delhi: Ministry of Non-conventional Energy Sources.

Table 6

Potential for bagasse-based cogeneration in different states (MW)

State	*Potential*
Andhra Pradesh	200
Bihar	200
Gujarat	200
Karnataka	300
Maharashtra	1000
Punjab	150
Tamil Nadu	350
Uttar Pradesh	1000
Others	100
Total	**3500**

Source

MNES. 1999. Annual Report 1998/99. New Delhi: Ministry of Non-conventional Energy Sources.

Table 7

Details of livestock and dung production in different states/union territories: 1987

State/union territory	*Cattle (thousands)*	*Buffaloes (thousands)*	*Estimated wet dung production (million tonnes)*
State			
Andhra Pradesh	12374	8757	21.6
Arunachal Pradesh	311	12	23.8
Assam	7278	623	23.8
Bihar	20841	4872	22.4
Goa, Daman, and Diu	112	40	33.5
Gujarat	6240	4502	20.4
Haryana	2201	3828	34.5
Himachal Pradesh	2245	795	38.0
Jammu and Kashmir	2765	565	20.1
Karnataka	10175	4036	21.7
Kerala	3424	329	8.6
Madhya Pradesh	28549	7351	15.4
Maharashtra	16979	4753	33.5
Manipur	770	141	23.8
Meghalaya	587	28	23.8
Mizoram	50	5	23.8
Nagaland	203	15	23.8
Orissa	13576	1509	23.3
Punjab	2832	5577	33.2
Rajasthan	10922	6344	25.0
Sikkim	184	3	23.8
Tamil Nadu	9343	3129	28.0
Tripura	828	16	23.8
Uttar Pradesh	26323	18240	24.2
West Bengal	16511	965	21.7
* **Union territories**	244	333	—
All-India	**195867**	**76769**	**615.6**

* includes total of all union territories

Note

Assuming collection losses of 40% in the case of cattle dung and 20% in the case of buffalo dung, the availability of wet dung (all India) works out to be 433 million tonnes.

Sources

1 FAO. Production Yearbook (various issues). Rome: Food and Agriculture Organization.

2 Vimal O P and Tyagi P D (eds). 1984. Energy from Biomass. New Delhi: Agricol Publishing Company. 440 pp.

3 TERI. 1987. Potential for Renewable Energy Utilization in Andaman and Nicobar and Lakshadweep Islands. Submitted to the Department of Non-conventional Energy Sources, Government of India. New Delhi: Tata Energy Research Institute. 183 pp.

Table 8

Urjagram projects in different states: 31 December 1996

State	*Projects completed*	*Projects under implementation*
Andhra Pradesh	4	16
Arunachal Pradesh	—	1
Assam	1	2
Bihar	9	5
Gujarat	22	11
Haryana	5	1
Himachal Pradesh	1	1
Jammu and Kashmir	2	2
Karnataka	3	4
Kerala	—	3
Madhya Pradesh	22	11
Maharashtra	61	20
Orissa	7	11
Punjab	6	3
Rajasthan	8	18
Tamil Nadu	34	21
Tripura	2	—
Uttar Pradesh	51	34
West Bengal	6	4
Total	**244**	**168**

Source
MNES. 1997. Annual Report 1996/97. New Delhi: Ministry of Non-conventional Energy Sources.

For more details, please see TEDDY ONLINE+ [Section: Renewables (biogas)]

Table 9

Biomass power capacity of different states (MW): 31 March 1998

State	*Total installed capacity*		*Capacity under implementation*
	1996/97	*1997/98*	
Andhra Pradesh	—	—	10.50
Gujarat	—	—	0.50
Haryana	4.00	—	—
Karnataka	1.00	—	50.00
Madhya Pradesh	—	—	5.00
Maharashtra	9.00	—	—
Punjab	10.00	—	12.00
Tamil Nadu	38.50	33.50	14.00
Uttar Pradesh	6.50	8.00	27.00
Total	**69.00**	**41.50**	**119.50**

Source
MNES. 1998 Annual Report 1997/98. New Delhi: Ministry of Non-conventional Energy Sources.

Table 10

Installation (number) of solar photovoltaic systems in different states/union territories: 31 December 199

State/union territory	Lighting Solar lantern	Homelighting system	Streetlighting system	Power plants (kWp)	Water pumps
State					
Andhra Pradesh	5963	730	2932	17.60	345
Arunachal Pradesh	1518	52	720	7.90	—
Assam	175	700	98	1.00	45
Bihar	5800	6	619	—	86
Gujarat	3663	370	1564	14.00	16
Goa	—	31	38	1.70	14
Haryana	5018	6	577	24.30	16
Himachal Pradesh	6000	934	304	—	1
Jammu and Kashmir	2625	1051	889	—	15
Karnataka	300	—	441	—	93
Kerala	9810	965	513	4.70	240
Madhya Pradesh	1348	100	5427	9.00	11
Maharashtra	3792	72	2941	6.40	102
Manipur	767	—	351	5.00	1
Meghalaya	2055	230	588	30.50	—
Mizoram	—	—	—	—	—
Nagaland	—	8	271	6.00	—
Orissa	1846	252	2036	33.50	1
Punjab	682	—	60	2.00	77
Rajasthan	722	—	5545	113.50	121
Sikkim	196	31	93	—	—
Tamil Nadu	889	50	1940	26.00	424
Tripura	—	—	—	—	—
Uttar Pradesh	28250	35585	470	419.00	62
West Bengal	2102	1282	952	42.10	42
Union territory					
Andaman and Nicobar Islands	234	390	315	129.10	5
Chandigarh	—	—	—	—	7
Dadra and Nagar Haveli	—	—	—	—	1
Delhi	4508	—	371	5.00	33
Lakshadweep	442	—	514	25.00	—
Pondicherry	215	—	—	—	14
Daman and Diu	—	—	—	—	—
Misc. (through agencies)	—	—	—	—	—
Total	**88920**	**42845**	**30569**	**923.30**	**1772**

Source

MNES. 1997. Annual Report 1996/97. New Delhi: Ministry of Non-conventional Energy Sources.

For more details, please see TEDDY ONLINE+ [Section: Renewables (solar)]

Table 11

Ultimate potential of windfarms in select states/districts

State/district	Wasteland (km^2)	Ultimate potential (MW)	Wind speed (m/s)	Specific output at 25 miles per hour (kWh/kW/year)	Cost of electricity of wind energy generators (Rs/kWh)	Potential generation (GWh)
Gujarat						
Kachch	38640	82998	5.25	1607	2.87	2668123
Jamnagar	7280	15637	5.68	1945	2.37	608281
Rajkot	3300	7088	5.57	1858	2.48	263340
Junagad	3080	6615	5.58	1866	2.47	246814
Bhavnagar	4400	9451	5.35	1685	2.74	318466
Total	**56700**	**121789**	**5.49**	**8961**	**2.59**	**4105024**
Maharashtra						
Ratnagiri	5980	12845	5.22	1584	2.91	406994
Orissa						
Puri	2700	5799	5.15	1531	3.01	177528
Baleshwar	1440	3098	5.04	1447	3.19	89682
Total	**4140**	**8897**	**5.10**	**2978**	**3.10**	**267210**
Tamil Nadu						
Ramanathapuram	5850	12565	5.16	1538	3.00	386575
Coimbatore	2220	4768	5.38	1708	2.70	162895
Tirunelveli	4950	10632	5.38	2073	2.23	440770
Kanyakumari	440	945	6.43	2546	1.81	48126
Total	**13460**	**28910**	**5.59**	**7865**	**2.44**	**1038366**

Source

TERI. 1995. Environmental Considerations and Options in Managing India's Long-term Energy Strategy (ECOMILES). p. 136. New Delhi: Tata Energy Research Institute. 241 pp.

Table 12

Details of WMS (wind monitoring stations) in India

Station	Location		Elevation (metres above sea level)	Wind speed (kmph)	Date of WMS establishment	Some of the prominent installations at sites (MW) (as on 31 March 1997)	
	Latitude	Longitude				Demonstration	Private
Tamil Nadu							—
Alagiyapandiyapuram	8°54'	77"39'	70	20.88	19.07.88	—	—
Andipatti	9°59'	77°35'	296	18.96	18.08.86	—	—
Arasanpalayam	10°49'	77°3'	385	20.18	24 05 90	—	—
Ayikudy	9°1'	77°20'	182	21.35	21.07.88	—	—
# Devarkulam	—	—	—	—		—	—
Edayarpalayam	10°54'	77°6'	445	22.43	28.05.90	0	4 5
Kattadimalai	8°17'	77°32'	35	23.66	22.07.88	—	—
Kayattar	8°57'	77°46'	105	20.29	21.08.19	10 52	38.98
Kethanur	10°53'	77°17'	404	21 91	21.05.90	2	55 88
Kumarapuram	8°16'	77°35'	158	21 97	03 12 92	—	—
Meenakshipuram	9°52'	77°18'	290	18.98	18.08.86	—	—
Mettukadai	10°55'	77°20'	418	17 99	22 05.90	—	—
Muppandal	8°15'	77°33'	42	25.48	21.08.86	4	339.955
Naduvakkurichi	9°5'	77°28'	172	16.61	27 06.92	—	—
# Nagum	—	—	—	—		—	—
Nettur	8°54'	77°33'	100	19.85	07.12 92	—	—
Omankulum	8°58'	77°51'	100	19 91	04 12.92	—	—
Ottapidaram	8°54'	78°1'	15	18.48	25 06.91	—	—
Pongalur	10°56'	77°23'	365	19 43	25.05 90	—	—
Poolavadi	10°45'	77°16'	390	21.16	13 08 86	—	156 745
Poompuhar	11°8'	79°51'	2	17.31	22 06.91	—	—
Poosaripatti	10°40'	77°7'	380	19 33	15.12 92	—	—
Puliyamkulam	8°21'	77°44'	10	18.93	26 08 86	1.59	—
Rameshwaram	9°17'	79°20'	4	23 91	24 07 88	—	—
Sembagaramanpudur	8°16'	77°77'	31	40 00	22.08 86	—	—
Sultanpet	10°54'	77°13'	398	18.96	28 07.86	0.09	48.575
Talayathu	8°47'	77°39'	125	20 51	18.07.88	—	—
Tuticorin	8°50'	78°8'	3	17.62	31.08 86	1.155	—
# Vanikundal	—	—	—	—	—	—	—
Total	—	—	—	—	—	19 355	655 520
Gujarat						—	—
Adesar	23°33'	70°57'	23	15 61	13 06.88	—	—
Bamanbore-1	22°25'	71°2'	167	15.47	07.02 88	—	— *
Bamanbore-II	22°25'	71°2'	235	20 28	28 10.90	—	—
Bhandaria	22°6'	69°43'	106	19 52	22.12.92	—	—
Dahod	22°51'	74°11'	167	16.98	26.05.88	—	—
Dandi	20°53'	72°51'	3	14 50	02.06.88	—	—
Dhank-1	21°46'	70°8'	175	24.44	28.10.90	1	61.750 *
Dhank-II	21°46'	70°8'	208	25.07	28.10 90	—	—
Harshad	21°51'	69°20'	12	20 02	07 12.86	—	—
Jafrabad	20°44'	71°24'	11	17 54	15 06 88	—	—
Jamanvada	23°35'	68°36'	57	18 62	22 02.92	—	—
Kalyanpur	22°3'	69°24'	92	22.06	31 10 90	0	8 38
Kukma	23°11'	69°47'	205	19 19	14 08 90	—	—
Lamba	21°54'	69°19'	20	19.97	22 12 92	10 20	31 72
Limbara	22°34'	70°59'	110	19.08	25 12.92	—	—
# Mandvi	—	—	—	—		1 49	0
Motisindholi	23°8'	68°47'	5	17 52	28 05 88	—	—
Mundra	22°42'	69°47'	4	19 54	29 05 88	—	—
Navadra	21°57'	69°16'	24	20 80	23 12 92	—	17 725
Navibandar	21°35'	69°40'	10	19 46	14.06 88	—	—
Okha	22°25'	69°1'	3	19 43	08 12.86	0 66	0
Okhamadhi	22°6'	69°6'	12	19 05	14 06 88	3 30	2
Saputara	20°35'	73°45'	950	11.63	03.06 88	—	—
Surajbari	23°14'	70°42'	9	19.53	13 06 88	—	—
# Tuna	—	—	—	—		0 695	0
Velan	20°42'	70°48'	12	15 90	15 06 88	—	—
Veraval	20°55'	70°15'	4	17 56	31.05.88	—	—
Total	—	—	—	—		17.345	121.57

Note

Mean yearly wind speed as recorded by IITM wind mast

* Dhank I and II wind monitoring station is situated at Dhank site, and the nearby sites are Pransla, Risalka, and Mervadar

# shows wind farm sites, where the data of the wind speeds are not published

(contd)

Table 12 contd

Station	Location		Elevation (metres above sea level)	Wind speed (kmph)	Date of WMS establishment	Some of the prominent installations at sites (MW) (as on 31 March 1997)	
	Latitude	Longitude				Demonstration	Private
Andhra Pradesh							
Bhimunipatnam	17°54'	83°34'	100	19 11	03 09 88	—	—
Jamalamadugu I	14°49'	78°23'	23	16 97	12 12 92	—	—
Jamalamadugu II	14°46'	78°22'	22	18 22	11 12 92	—	—
Kadavakallu	14°48'	77°56'	56	22 06	04 12 92	—	—
Kakulakonda	13°43'	79°18'	981	23 08	24.08 88	—	—
MPR Dam	14°51'	77°33'	450	19 85	27 08 88	—	—
Mustikovala	14°15'	77°32'	32	20 16	18 08 92	—	—
Narasimhakonda	14°30'	79°52'	100	20 08	31 08 88	—	—
Payalakuntla	14°53'	79°2'	642	20 09	25 08 88	—	—
Ramagiri	14°18'	77°30'	667	19 68	28 08 88	—	—
Ramagiri III	14°18'	77°30'	30	19 38	27.09 92	—	—
Ramagiri-I	14°18'	77°30'	667	19 52	28 08 88	2	51 240 **
Ramanaidu kandrika	13°37'	78°29'	751	15 73	23 08 88	—	—
Singanamala	14°46'	77°44'	44	23 76	15.12 92	—	—
Tirumala	13°45'	79°22'	880	20 43	21 11 87	1 05	0
Yeradoddi	14°10'	78°7'	7	14 71	09 12 92	—	—
Total						**3.05**	**51.24**
Karnataka							
B.B Hills	13°26'	75°45'	1600	27 06	19 10 90	—	—
Bommanahalli	13°17'	76°36'	955	13 06	09 10 89	—	—
Byndoor	13°52'	74°38'	65	11 81	02 02 90	—	—
Gokak	16°7'	74°47'	775	18 93	05 10 89	—	—
Hanumanahatti	15°55'	74°43'	902	20 08	31 01 90	—	—
Hanumansagar	15°54'	76°2'	728	20 23	07 10 89	—	—
Haradenahalli	12°51'	76°13'	1030	18 22	23 12 92	—	—
Jogimatti	14°10'	76°22'	1132	29 97	08 10 89	—	—
Kappatagudda	—	—	—	—	—	2 025	1 35
Malgatti	15°52'	75°55'	721	19 32	06 10 89	—	—
Sangundi	16°15'	75°44'	625	18 56	06 07 91	—	—
Talacaveri	—	—	—	—	—	0 55	0
Total						**2.575**	**3.27**
Madhya Pradesh							
Jamgodrani	22°59'	76°10'	560	18 44	12 03 92	—	9
Kheda	22°36'	75°38'	618	18 6	10 03 92	0 59	—
Mirzapur	23°1'	76°41'	480	14 74	12 03 92	—	—
Total						**0.59**	**9**
Maharashtra							
Chalkewadi	17°31'	73°46'	1150	20 17	11 12 88	2	0 77
Deogad	16°17'	73°18'	36	16 47	16 12 86	1 1	0
Deogad	16°17'	73°18'	36	16.47	16 12.86	—	—
Gude Panchgani	17°7'	73°59'	900	19 83	17 01 93	—	—
Lonavla	18°45'	73°25'	660	15 52	05 06 88	—	—
Malwan	16°1'	73°19'	35	13 68	18 12 86	—	—
Malwan	16°1'	73°19'	35	13 38	18 12.86	—	—
Panchgani	17°49'	73°46'	1372	18 39	10 12 88	—	—
Sapthasringigad	20°24'	73°54'	1200	17 82	06 02 91	—	—
Vengurla	15°47'	73°33'	35	13 63	09 12 88	—	—
Vijayadurg	16°31'	73°17'	36	19 61	17 12 86	—	—
Vijayadurg	16°31'	73°17'	36	19 61	17 12 86	—	—
Total						**3.1**	**0.77**
Orissa							
Chandipur	21°32'	87°1'	5	15 16	10 09 86	—	—
Chatrapur	19°18'	84°58'	9	14 24	15 09 86	—	—
Gopalpur	19°16'	84°54'	8	14 29	15 09 86	—	—
Kaipadar 1	20°7'	85°37'	84	15 56	08 09 86	—	—
Marine Drive	19°51'	86°3'	2	12 23	13 09 86	—	—
Paradip	20°23'	86°41'	6	17 79	11 09 86	—	—
Puri	19°48'	85°49'	2	17 38	03 09 86	1 1	0
Total						**1.1**	**0**

(contd)

** Ramagiri I II, and III lie within the main Ramagiri site

shows wind farm sites, where the data of the wind speeds are not published

Table 12 contd

Station	Location		Elevation (metres above sea level)	Wind speed (kmph)	Date of WMS establishment	Some of the prominent installations at sites (MW) (as on 31 March 1997)	
	Latitude	Longitude				Demonstration	Private
Kerala							
Gopalapuram	10°41'	76°52'	200	12.81	05.01.90	—	—
Kanjikode	10°47'	76°49'	130	22.32	04.01.90	2 025	0
Kolahalamedu	9°40'	76°56'	1000	16.87	25.11.92	—	—
Kottamala	10°40'	76°36'	150	18.41	23.09.90	—	—
Kottathara	11°7'	76°39'	750	19 4	08.01.90	—	—
Kundaly	10°9'	77°11'	1800	9.09	21.09.90	—	—
Panchalimedu	9°32'	76°57'	950	20.39	23.11.92	—	—
Ponmudi	8°46'	77°8'	1074	18.33	19.09.90	—	—
Ramakalmedu	9°49'	77°14'	920	30.29	07.08.91	—	—
Tholanur	10°42	76°30'	100	15.86	22 09.90	—	—
Total						**2.025**	**0**
Rajasthan							
Barli	26°19'	72°54'	34	16.15	28 12 88	—	—
Bhadkha	26°0'	71°23'	193	15.1	26 12.88	—	—
Bishengarh	25°27'	72°35'	147	11.04	20 02.91	—	—
Derasar	25°46'	71°12'	218	12.68	25 12 88	—	—
Jaisalmer	26°54'	70°55'	231	17.37	08 06.88	—	—
Khodal	26°22'	71°14'	200	16.82	23.12 88	—	—
Mohangarh	27°17'	71°13'	155	14.47	26 04.90	—	—
Pachpadra	25°55'	72°12'	112	12.06	24.12.88	—	—
Phalodi	27°8'	72°20'	234	17.35	29.12 88	—	—
Lakshadweep							
Agathi	10°51'	72°11'	1	18 22	25.10.89	—	—
Kadmat	11°13'	72°47'	1	18	21.10 89	—	—
Kalpeni	10°5'	73°39'	1	15 94	19 12.89	—	—
Kavarathi	10°32'	72°38'	1	17.71	23.08.89	—	—
Minicoy	8°17'	73°4'	1	18.29	31.10.92	—	—
Others						**0.465**	—
Grand total						**51.105**	**849.265**

Sources

1 Mani A. Wind Energy Resource Survey in India. Vol. I II, III, IV New Delhi: Allied Publishers.

2 MNES. 1997 New Delhi. Ministry of Non-conventional Energy Sources

For more details, please see TEDDY ONLINE+ [Section: Renewable (wind)]

Table 13

Distribution of wind power densities in different states

State/union territory	Number of stations	Number of stations having mean average wind power density (W/m²) Greater than 100	Greater than 150	Greater than 200
State				
Andhra Pradesh	26	22	14	7
Gujarat	25	19	11	3
Karnataka	16	14	8	3
Kerala	12	10	7	3
Lakshadweep	5	5	3	0
Madhya Pradesh	6	3	0	0
Maharashtra	12	10	3	0
Orissa	8	5	0	0
Rajasthan	11	4	0	0
Tamil Nadu	33	32	27	18
Union territory				
Andaman and Nicobar Islands	5	—	0	0

Source

MNES Annual Report (various issues). New Delhi. Ministry of Non-conventional Energy Sources.

Table 14

Wind power installed capacity (MW): 30 September 1998

State	Demonstration projects	Private sector projects	Total capacity
Andhra Pradesh	3.05	54.74	57.79
Gujarat	17.35	149.56	166.91
Karnataka	2.58	15.69	18.27
Kerala	2.02	—	2.02
Madhya Pradesh	0.59	17.86	18.45
Maharashtra	4.60	3.52	8.12
Orissa	1.10	—	1.10
Tamil Nadu	19.36	699.52	718.88
Others	0.47	—	0.47
Total	**51.11**	**940.88**	**991.99**

Source

MNES. 1999. Annual Report 1998/99 New Delhi. Ministry of Non-conventional Energy Sources.

For more details, please see TEDDY ONLINE+ [Section: Renewables (wind)]

Table 15

Identified small hydel power project sites up to 15 MW capacity in different states of India : March 1999

State/union territory	*Sites identified up to 3 MW*		*Sites identified between 3 and 15 MW*		*Total*	
	Number	*Capacity (MW)*	*Number*	*Capacity (MW)*	*Number*	*Capacity (MW)*
State						
Andhra Pradesh	271	114.9	13	95.75	284	210.63
Arunachal Pradesh	433	382.3	49	460.72	482	843.03
Assam	38	50.0	8	68.00	46	118.00
Bihar	158	199.4	7	53.60	165	252.97
Goa	3	2.6	—	—	3	2.60
Gujarat	283	113.3	7	43.50	290	156.83
Haryana	21	24.1	1	6.00	22	30.05
Himachal Pradesh	166	216.0	150	1259.75	316	1475.78
Jammu and Kashmir	106	145.5	78	728.75	184	874.27
Karnataka	181	166.1	44	384.50	225	550.61
Kerala	167	199.1	28	203.75	195	402.85
Madhya Pradesh	99	74.6	19	188.50	118	263.13
Maharashtra	183	123.6	42	307.90	225	431.47
Manipur	91	59.8	4	29.88	95	89.63
Meghalaya	83	41.0	13	97.50	96	138.50
Mizoram	73	42.3	13	101.00	86	143.32
Nagaland	67	26.9	17	117.50	84	144.39
Orissa	152	88.8	9	68.00	161	156.76
Punjab	78	65.3	—	—	78	65.26
Rajasthan	49	27.3	—	—	49	27.26
Sikkim	52	56.3	16	146.50	68	202.75
Tamil Nadu	131	141.9	11	90.00	142	231.92
Tripura	8	9.9	—	—	8	9.85
Uttar Pradesh	310	326.6	129	1039.30	439	1365.93
West Bengal	141	153.9	4	28.75	145	182.62
Union territory						
Andaman and Nicobar Islands	5	1.2	—	—	5	1.15
Grand total	**3349**	**2852.4**	**662**	**5519.15**	**4011**	**8371.56**

Source

MNES. 1999. Annual Report 1998/99. New Delhi: Ministry of Non-conventional Energy Sources.

For more details, please see TEDDY ONLINE+ [Section: Renewables (hydro and wind)]

Table 16

List of small hydro power stations installed/under construction up to 3 MW station capacity in various states: 1997

State/union territory	*Projects installed* Number	*Projects installed* Capacity (MW)	*Projects under construction* Number	*Projects under construction* Capacity (MW)
State				
Andhra Pradesh	11	15.21	32	33.90
Arunachal Pradesh	30	21.05	17	20.63
Assam	2	2.20	—	—
Bihar	4	0.04	5	2.46
Gujarat	1	2.00	—	—
Haryana	1	0.20	1	0.10
Himachal Pradesh	14	9.49	18	11.19
Jammu and Kashmir	17	8.37	10	13.31
Karnataka	12	17.20	18	23.17
Kerala	5	5.52	5	9.50
Madhya Pradesh	5	3.25	3	5.00
Maharashtra	5	6.82	3	5.45
Manipur	6	4.10	4	3.50
Meghalaya	1	1.51	7	0.28
Mizoram	9	5.36	5	7.75
Nagaland	5	3.17	3	3.70
Orissa	3	1.26	7	9.92
Punjab	4	3.90	8	9.50
Rajasthan	5	4.32	1	0.54
Sikkim	8	9.25	2	3.20
Tamil Nadu	3	4.75	4	6.40
Tripura	2	1.01	1	0.10
Uttar Pradesh	62	32.64	26	12.93
West Bengal	9	7.98	5	6.03
Union territory				
Andaman and Nicobar Islands	—	—	1	2.25
Total	**224**	**170.60**	**186**	**190.81**

Source
MNES Annual Report (various issues). New Delhi. Ministry of Non-conventional Energy Sources

For more details, please see TEDDY ONLINE+ [Section: Renewables (hydro and wind)]

Table 17

Coverage of estimated potential of biogas plants up in different states/union territory to March 1998

	Number of biogas plants		
State/union territory	*Total estimated potential*	*Plants installed so far*	*Coverage of potential (%)*
State			
Andhra Pradesh	1065600	237180	22
Arunachal Pradesh	7500	411	5
Assam	307700	29026	9
Bihar	939900	105517	11
Goa	8000	2847	36
Gujarat	554000	314074	57
Haryana	300000	35017	12
Himachal Pradesh	125600	40688	32
Jammu and Kashmir	128500	1653	1
Karnataka	680000	234683	35
Kerala	150500	53641	36
Madhya Pradesh	1491200	151070	10
Maharashtra	897000	613529	68
Manipur	38700	1491	4
Meghalaya	24000	514	2
Mizoram	2200	1476	67
Nagaland	6700	793	12
Orissa	605500	145498	24
Punjab	411600	43307	11
Rajasthan	915300	63051	7
Sikkim	7300	1994	27
Tamil Nadu	615800	192163	31
Tripura	28500	792	3
Uttar Pradesh	2021000	310616	15
West Bengal	695000	132937	19
Union territory			
Andaman and Nicobar Islands	2200	130	6
Chandigarh	1400	97	7
Dadra and Nagar Haveli	2000	168	8
Delhi	12900	671	5
Pondicherry	4300	539	13
Total	**12049900**	**2713470**	**22.52**

Source

MNES 1999 Annual Report 1998/99. New Delhi: Ministry of Non-conventional Energy Sources.

Table 18

National Project on Biogas Development· achievements and targets (numbers)

State	*Annual target*	*Achievement (April–December 1998)*
Andhra Pradesh	14000	9848
Arunachal Pradesh	100	–
Assam	500	61
Bihar	500	580
Goa	75	70
Gujarat	10200	948
Haryana	1500	955
Himachal Pradesh	750	442
Jammu and Kashmir	50	–
Karnataka	12500	796
Kerala	1000	280
Madhya Pradesh	13000	2297
Maharashtra	12000	3050
Manipur	200	130
Meghalaya	100	–
Mizoram	200	112
Nagaland	200	–
Orissa	6000	3054
Punjab	8000	3676
Rajasthan	1000	574
Sikkim	200	166
Tamil Nadu	1500	907
Tripura	100	9
Uttar Pradesh	8500	4276

Source
MNES 1999 Annual Report 1998/99 New Delhi Ministry of Non-conventional Energy Sources.

Table 19

CBP/IBP/NBP (community biogas plants/institutional biogas plants/night-soil biogas plants) programm state/union territory plants set up to the year 1997/98 and targets allocated for 1998/99

State/union territory/agency	*Number of large-sized plants set up under CBP/IBP/NBP*	*Number of plants (Allocated target)*
State		
Andhra Pradesh	71	2
Assam	2	2
Bihar	15	1
Gujarat	124	5
Haryana	14	5
Himachal Pradesh	3	0
Jammu and Kashmir	4	0
Karnataka	18	5
Kerala	5	2
Madhya Pradesh	96	3
Maharashtra	295	40
Nagaland	0	10
Orissa	33	5
Punjab	341	40
Rajasthan	48	10
Tamil Nadu	112	10
Uttar Pradesh	439	40
West Bengal	32	10
Union territory		
Pondicherry	1	0
Delhi	17	0
Agency		
Khadi and Village Industries Commission	0	150
Sulab International	0	10
Total	**2362**	**350**

Source
MNES 1999 Annual Report New Delhi Ministry of Non-conventional Energy Sources

Table 20

Distribution of family-type biogas plants by state/union territory (number of installations): 1990/91 to 1997/98

State/union territory	Total estimated potential	As on 31 March 1990	Additions							As on 31 December 1996 †	Additions 1997/98
			1990/91	1991/92	1992/93	1993/94 *	1994/95 *	1995/96 *	1996/97*		
State											
Andhra Pradesh	1065600	89327	8578	13777	14269	10291	9453	20632	6083	172410	18929
Arunachal Pradesh	7500	24	28	37	—	7	11	15	17	139	65
Assam	307700	8557	1191	986	810	199	381	355	150	12629	138
Bihar	939900	58553	4313	5397	3502	898	662	892	282	74499	641
Goa	8000	1448	216	203	157	69	48	35	36	2212	242
Gujarat	554000	92908	26537	33086	35551	17858	8298	19308	4237	237513	12061
Haryana	300000	18129	1948	1997	2028	1001	1011	1773	1009	28896	1300
Himachal Pradesh	125600	20822	3668	3510	3401	1316	423	1231	500	34871	1142
Jammu and Kashmir	128500	708	185	62	40	4	19	20	30	1068	0
Karnataka	680000	65968	6586	8600	15763	4306	9721	16721	7763	135428	12465
Kerala	150500	23471	3700	4436	2882	663	664	1250	308	37374	2765
Madhya Pradesh	1491200	37332	3637	4135	8035	6773	5004	18220	3325	86461	15269
Maharashtra	897000	370662	50384	51085	28465	10590	6577	12362	5154	535279	61671
Manipur	38700	339	77	116	150	77	50	142	87	1038	271
Meghalaya	24000	167	52	50	60	—	—	—	—	329	0
Mizoram	2200	591	120	78	120	56	55	82	76	1178	147
Nagaland	6700	124	—	—	—	—	20	182	75	401	121
Orissa	605500	48407	13022	8386	12521	6182	4806	12024	808	106156	7164
Punjab	411600	14802	2393	2197	2144	1702	2052	3464	2481	31235	5524
Rajasthan	915300	34864	3518	4169	3139	2421	2502	4047	644	55304	1526
Sikkim	7300	364	175	275	214	122	104	224	144	1622	174
Tamil Nadu	615800	127096	9983	9184	8112	5250	5167	4029	784	169605	1084
Tripura	28500	114	50	110	65	4	3151	51	31	3576	72
Uttar Pradesh	2021000	180806	17063	12414	10447	4330	—	10616	5720	241396	8463
West Bengal	695000	40474	8702	7121	5942	3629	1	6620	4224	76713	10974
Union territory											
Andaman and Nicobar Islands	2200	98	—	—	10	—	—	5	4	117	5
Chandigarh	1400	77	1	4	—	—	—	5	—	87	0
Dadra and Nagar Haveli	2000	133	10	6	5	—	—	3	—	157	0
Daman and Diu	100	—	—	—	—	1	—	—	—	1	0
Delhi	12900	578	22	17	4	—	—	3	—	624	3360
Lakshadweep	—	—	—	—	—	—	—	—	—	—	0
Pondicherry	4300	447	25	18	25	2	—	—	—	517	0
Others	—	—	—	—	30242	11226	12478	37264	12884	104094	0
Total	12050000	1237390	166184	171456	188103	88977	72658	171305	56856	215299	165573

* figures correspond to installations from April to December

† these figures are lower estimates of the actual installations

Source
Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section Renewables (biogas)]

Table 21

Distribution of biomass gasifier/Stirling engine systems in states/union territory (sanctioned and installed): up to 1997/98

State/union territory	Cumulative achievement (till March 1995)		Systems installed (April–December 1996)		Systems sanctioned (April–December 1996)		Systems installed (1997/98)		Systems sanctioned (1997/98)		Systems installed (April–December 1998)	
	Number of systems	Capacity (kW)	Number of systems	Capacity (MW)	Number of systems	Capacity (MW)	Number of systems	Capacity (MW)	Number of systems	Capacity (MW)	Number of systems	Capacity (MW)
State												
Andhra Pradesh	87	3395.1	56	1300	—	—	10	1000	27	3040	23	2300
Arunachal Pradesh	10	320.0	—	—	—	—	—	—	—	—	—	—
Assam	7	36.4	—	—	—	—	—	—	1	300	—	—
Bihar	2	20.0	—	—	—	—	—	—	—	—	—	—
Goa	3	30.0	—	—	—	—	—	—	—	—	—	—
Gujarat	209	5281.8	1	40	1	100	1	5	2	10	1	5
Haryana	30	1701.7	—	—	—	—	—	—	—	—	—	—
Himachal Pradesh	2	7.4	—	—	—	—	—	—	—	—	—	—
Jammu and Kashmir	4	120.0	—	—	—	—	—	—	—	—	—	—
Karnataka	468	2328.9	1	20	—	—	5	860	10	1820	1	500
Kerala	10	614.8			—	—	—	—	—	—	—	—
Madhya Pradesh	159	10652.0	6	300	—	—	—	—	1	100	1	100
Maharashtra	311	2062.2	1	500	5	700	—	—	—	—	1	100
Manipur	—	—	—	—	—	—	—	—	—	—	—	—
Meghalaya	—	—	—	—	—	—	—	—	—	—	—	—
Mizoram	—	—	—	—	—	—	—	—	—	—	—	—
Nagaland	—	—	—	—	—	—	—	—	—	—	—	—
Orissa	15	61.8	—	—	—	—	—	—	—	—	1	10
Punjab	78	3145.0	—	—	—	—	—	—	—	—	—	—
Rajasthan	24	438.9	—	—	—	—	—	—	—	—	—	—
Sikkim	—	—	—	—	—	—	—	—	—	—	—	—
Tamil Nadu	59	800.8	1	400	—	—	7	130	11	400	3	70
Tripura	—	—			—	—	—	—	—	—	—	—
Uttar Pradesh	35	511.4			—	—	—	—	—	—	—	—
West Bengal	—	—	1	500	—	—	5	500	0	0	—	—
Union territory												
Andaman and Nicobar Islands	17	167.4	—	—	—	—	—	—	—	—	—	—
Chandigarh	—	—	—	—	—	—	—	—	—	—	—	—
Dadra and Nagar Haveli	—	—	—	—	—	—	—	—	—	—	—	—
Delhi	16	74.0	—	—	—	—	—	—	—	—	—	—
Lakshadweep	—	—	—	—	—	—	—	—	—	—	—	—
Pondicherry	—	—	—	—	—	—	—	—	—	—	—	—
Others	58	318.3	—	—	—	—	—	—	—	—	—	—
Total	**1604**	**32087.8**	**67**	**3060**	**6**	**800**	**28**	**2495**	**52**	**5670**	**31**	**3085**

Source
MNES 1998 Annual Report 1998/99 New Delhi: Ministry of Non-conventional Energy Sources.

Table 22

National Programme on Improved Chulhas (targets and achievements): April–December 1998

State/union territory/agency	*Annual target*	*Achievement (April–December 1998)*
State		
Andhra Pradesh	100000	49198
Arunachal Pradesh	10000	—
Assam	12000	374
Bihar	20000	1185
Gujarat	60000	33747
Goa	5000	754
Haryana	40000	10054
Himachal Pradesh	15000	6998
Jammu and Kashmir	43000	—
Karnataka	40000	4760
Kerala	80000	11466
Madhya Pradesh	100000	12240
Maharashtra	100000	865
Manipur	10000	242
Meghalaya	8500	—
Mizoram	10000	1300
Nagaland	8500	115
Orissa	100000	69151
Punjab	75000	—
Rajasthan	75000	1081
Sikkim	5000	3451
Tamil Nadu	60000	54436
Tripura	15000	3600
Uttar Pradesh	100000	49738
West Bengal	100000	86042
Union territory		
Andaman and Nicobar Islands	1500	1015
Dadra and Nagar Haveli	1200	736
Delhi	2000	—
Lakshadweep	300	64
Pondicherry	3000	1016
Agency		
Khadi and Village Industries Commission, Mumbai	370000	84523
National Diary Development Board	8000	2544
All India Women Conference	22000	5250
Total	**1600000**	**495945**

Source
MNES 1999 Annual Report. New Delhi Ministry of Non-conventional Energy Sources

Table 23

Average annual consumption of fuels before and after adoption of an improved chulha

Fuel	*Annual consumption before adoption of improved chulha*	*Annual consumption after adoption of improved chulha*	*Quantity of fuel saved per year*
Dung cake (kg)	860	609	251
Fire wood (kg)	633	530	103
Twigs (kg)	543	530	13
Crop wastes (kg)	276	271	5
Kerosene (litre)	8	5	3

Source
MNES 1999 Annual Report New Delhi: Ministry of Non-conventional Energy Sources.

Table 24

Distribution of improved cookstoves in different state/union territory (number of installations): 1990 to 1998

State/union territory	*31 March 1990*	*31 March 1995*	*31 March 1996*	*1 April 1998*
State				
Andhra Pradesh	657221	1592599	1879811	2215911
Arunachal Pradesh	4042	29593	29593	30518
Assam	61357	254484	269508	272308
Bihar	422751	860559	864315	871267
Goa	38379	86296	93193	100914
Gujarat	439263	822795	876295	1002743
Haryana	490579	776628	811116	824921
Himachal Pradesh	303940	528527	554964	585955
Jammu and Kashmir	123476	256796	291796	305796
Karnataka	357807	945869	1009742	1053267
Kerala	152048	447573	549010	612642
Madhya Pradesh	685000	1679526	1897625	2147508
Maharashtra	521286	1385320	1535383	2716189
Manipur	15576	47004	52016	58306
Meghalaya	10200	12200	12200	12200
Mizoram	5194	20194	23194	27344
Nagaland	7000	9565	10165	11377
Orissa	247283	894480	1106943	1295255
Punjab	418995	791429	852429	918229
Rajasthan	904711	1855424	1986221	2126699
Sikkim	14175	35965	41173	49010
Tamil Nadu	632378	1441604	1620424	1730305
Tripura	4361	12669	16928	29166
Uttar Pradesh	997591	2490820	2741264	3026155
West Bengal	248300	663911	842918	1094763
Union territory				
Andaman and Nicobar Islands	8260	22243	24559	27226
Chandigarh	8498	15944	16044	16044
Dadra and Nagar Haveli	3979	8993	9926	11969
Daman and Diu	—	28175	—	—
Delhi	89632	194080	215699	229839
Lakshadweep	3278	6065	6646	6912
Pondicherry	12732	19617	21977	28125
Others	501056	1375134	1930228	2258547
Total	**8390348**	**19611272**	**43794993**	**25697410**

Source

MNES. Annual Report (various issues) New Delhi Ministry of Non-conventional Energy Sources

For more details, please see TEDDY ONLINE+ [Section: Renewables (biogas)]

Table 25

Distribution of solar thermal systems in different state/union territory (number): 31 March 1993

State/union territory/agency	*Industrial SWHS (solar water heating systems)*	*Domestic SWHS*	*Solar air-heated crop-drying systems*	*Solar timber kilns*	*Solar desalination systems*	*Solar cookers*
State						
Andhra Pradesh	150	118	2	2	486	3015
Assam	49	*	3	—	56	80
Arunachal Pradesh	67	—	1	1	53	—
Bihar	51	—	—	—	—	730
Goa	43	42	—	—	—	794
Gujarat	1561	5521	9	18	5300	31059
Haryana	198	36	—	1	120	12720
Himachal Pradesh	143	819	2	3	3	13349
Jammu and Kashmir	72	43	—	—	70	—
Karnataka	340	1657	1	2	—	—
Kerala	59	51	2	—	4	171
Madhya Pradesh	301	177	2	1	150	97732
Maharashtra	571	632	1	—	145	37114
Manipur	24	16	—	—	21	200
Meghalaya	44	2	—	—	—	732
Mizoram	3	—	—	—	—	70
Nagaland	13	—	—	—	—	—
Orissa	95	—	2	—	398	769
Punjab	392	236	—	6	188	8683
Rajasthan	230	20	—	—	438	29483
Sikkim	26	21	—	—	—	20
Tamil Nadu	267	1945	3	1	1	1304
Tripura	13	—	—	—	28	—
Uttar Pradesh	645	255	27	30	586	22523
West Bengal	92	1	5	1	75	2271
Union territory						
Andaman and Nicobar Islands	18	—	—	—	—	730
Chandigarh	74	33		1	55	918
Dadra and Nagar Haveli	3	—	—	—	2	
Delhi	539	872	1	4	1643	24172
Pondicherry	38	20	—	—	45	—
Agency						
Central Public Works Department	5	—	—	—	—	—
Indian Railways	16	—	—	—	328	—
Total	**6142**	**12517**	**61**	**71**	**10195**	**288028**

* indicates no distribution

Source

MNES Annual Report (various issues) New Delhi. Ministry of Non-conventional Energy Sources

For more details, please see TEDDY ONLINE+ [Section: Renewables (solar)]

Table 26

Urban population (million), potential availability (MTPA [million tonnes per annum]) of city refuse: 1971 to 1991

Item	*1971*	*1981*	*1991*
Urban population (million)	109.1	159.5	217.6
City refuse (MTPA)			
Non-compostable (60%)	9.6	14.0	19.1
Compostable (40%)	6.4	9.3	12.7
Total	**16.0**	**23.3**	**31.8**

Note

City refuse is equal to urban population x 0.4 kg per urban dweller per day x 365 days.

Sources

1 Vimal O P and Tyagi P D (eds). 1984. Energy from Biomass. New Delhi: Agricol Publishing Company. 440 pp.

2 CMIE. Basic Statistics Relating to the Indian Economy (various issues). Mumbai· Centre for Monitoring Indian Economy.

Table 27

Chemical characteristics of city refuse

	Population of city (million)			
Parameter	*Less than 0.2*	*0.2 to 0 5*	*0.5 to 2 0*	*Greater than 2.0*
Moisture (%)	22.1	25.1	22.4	31.2
pH (%)	8.2	8.2	8.3	7.7
* Organic matter (%)	22.0	22.5	21.5	27.6
* Carbon (%)	12.3	12.6	12.0	15.3
* Nitrogen (%)	0.6	0.6	0.6	0.6
* Phosphorus pentoxide (%)	0.7	0.7	0.7	0.6
* Potash (%)	0.7	0.7	0.7	0.7
Calorific value (kcal/kg)	801.0	874.0	867.0	1140.0

* on a dry weight basis

Source

Vimal O P and Tyagi P D (eds). 1984 Energy from Biomass. New Delhi: Agricol Publishing Company. 440 pp.

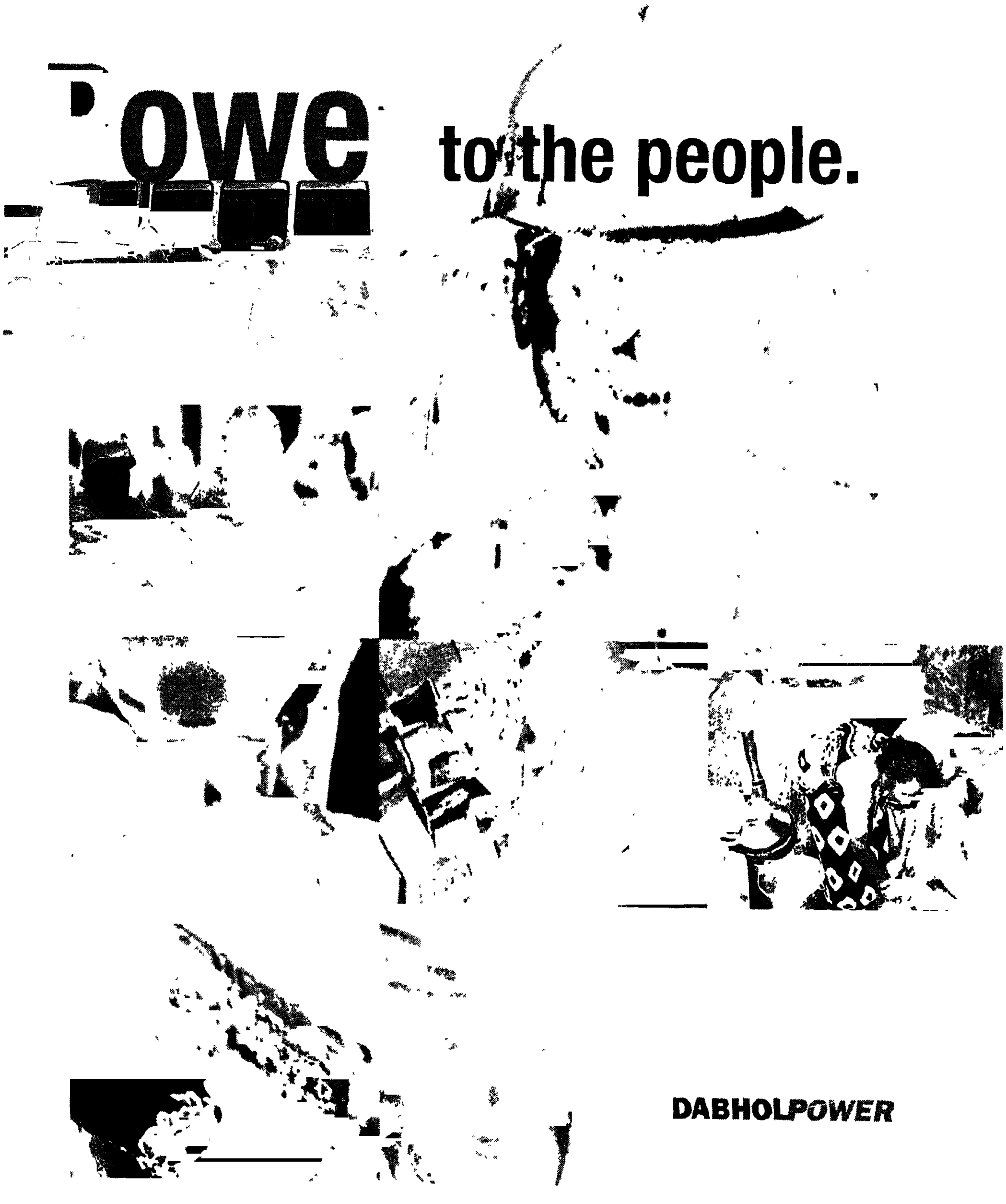
Table 28

Estimated potential for renewable energy technologies in India

Source/system	*Approximate potential*
Biogas plants (number)	12 million
Improved woodstoves	120 million
Biomass	17000 MW
Solar energy	20 MW/km^2
Wind energy	20000 MW
Small hydropower	10000 MW
Ocean energy	50000 MW

Source

MNES. 1999 Annual Report 1998/99. New Delhi: Ministry of Non-conventional Energy Sources.



DABHOLPOWER

Outlook

Introduction

This chapter provides the demand and supply projections for commercial energy, namely, coal, oil, gas, and power, for the Ninth Plan period and for the end of the Tenth and Eleventh Plan periods, wherever possible. The projections have been made by the respective working groups/sub-groups for the Ninth Five-Year Plan formulated by the Planning Commission, Government of India. The methodology adopted by each working group in making these estimates has also been described in brief. Wherever possible, these projections have been updated using the data published by the government. Based on the demand and supply projections, certain elementary inferences have been drawn by computing simple indicators like the CARG (compounded annual rate of growth), percentage self-reliance in oil, and the demand–supply gaps. Some of the factors that are likely to impact the future demand and availability of fuels have also been discussed briefly.

Projections for environmentally harmful emissions of particulate matter and oxides of sulphur, carbon, and nitrogen, resulting from energy use have also been provided.

Coal

The demand projections made by the Working Group on Coal and Lignite are based on the end-use analysis of power, cement, and iron and steel sectors (Planning Commission 1997). These projections remain unchanged, though they need to be validated in view of the factors that are likely to influence the future coal demand.

The annual average demand growth rate for coal projected for the Ninth Plan period is 3.73% (Table I). An annual growth rate of 3.8% has been estimated for coal production during this period. The projected production will be coming from existing mines as well as new projects.

Table I Short-term demand and supply forecasts (million tonnes)

Forecasts	*1997/ 98*	*1998/ 99*	*1999/ 2000*	*2000/ 01*	*2001/ 02*
Demand					
Coking coal	41.4	47.2	47.8	47.7	51.6
	(12.8)	(14.1)	(13.3)	(12.1)	(12.9)
Non-coking coal	282.0	286.8	312.1	345.1	353.4
	(87.2)	(85.9)	(86.7)	(87.9)	(87.1)
Total	323.4	334.0	359.9	392.8	405.7
Supply					
Opencast	216.2	226.6	235.0	244.3	253.6
	(72.4)	(72.8)	(72.9)	(73.0)	(73.2)
Underground	75.3	77.4	80.1	82.8	85.4
	(25.2)	(24.9)	(24.9)	(24.8)	(24.6)
Others	7.1	7.2	7.2	7.4	7.6
	(2.4)	(2.3)	(2.2)	(2.2)	(2.2)
Total	298.1	311.2	322.3	334.4	346.6
Demand growth rate (%)	3.98	3.27	7.75	9.25	3.28
Deficit (%)	25.3	22.8	37.6	58.4	59.1

Note

1. Figures in parentheses indicate percentages.
2. The difference in long- and short-term estimates may be explained by the difference in model assumptions and methodology.

Source Planning Commission (1997)

Underground mining has not been exploited adequately due to technological constraints. Hence, coal production from opencast mining is expected to constitute nearly 73% of the total coal produced in the year 2001/02. The over-exploitation of shallow reserves of coal by opencast mining may result in almost total dependence on underground production in the longer term. Hence a proper balance needs to be created in the underground–opencast technology mix.

By 2002, the demand–supply gap is estimated at 59 MT (million tonnes). This gap is expected to fill through increased imports of coking and non-coking coal.

The demand growth rate is expected to increase to 5.64% during the Tenth Plan period (Table II). This would be largely on account of planned addition of 116 GW of coal-based power generation capacity by the end of the period. The power sector being the largest consumer of non-coking coal constitutes about 87% of the total coal demand. In addition, the Ministry of Industry has projected a growth rate of eight per cent in cement demand for the Tenth Plan period, thus implying an increased coal demand. In the longer term, the deficits in supply of indigenous coal will lead to a switch to cleaner alternative fuels such as natural gas in the power sector, in addition to increased non-coking coal imports.

During the Eleventh Plan period, the demand growth rate is expected to decline to 2.89%. In addition to the demand-side management initiatives that will lead to a reduction in specific consumption (0.75 kg/kWh) and hence coal demand, the major issues that are likely to impact the availability and demand for indigenous coal in the future are (1) infrastructural bottlenecks, (2) pricing policies, and (3) environmental impacts of coal mining and utilization.

- *Infrastructure bottlenecks.* The constraints on railway capacity and network, and port-handling facilities need to be considered for arriving at a realistic demand for coal. The coal-based plants in the coastal locations, for instance, may find it more economical to use imported coal due to the long distances over which the domestic coal has to be transported.
- *Pricing policies.* The deregulation of prices for indigenous coal and reduction of duty on imported coal will facilitate a switch to imported coal especially at certain locations in southern and western regions.
- *Environmental impacts of coal mining and utilization.* The poor quality of coal coupled with stricter environmental norms will lead to a switch to cleaner fuels such as natural gas. In addition, environmental problems such as deforestation and rehabilitation associated with mining projects have also slowed down the development of new mines.

Table II Long-term demand and supply forecasts (million tonnes)

Forecast	2001/02	2006/07	2011/12
Demand	405	563	835
Domestic supply	347	417	575
Deficit	58	146	260
CARG* for demand (%)	3.73	5.64	2.89

* compounded annual rate of growth

Source Planning Commission (1997)

Oil

The product demand estimates have been made based on end-use analysis and by correlating the consumption of petroleum products to the growth in GDP (gross domestic product). The demand for petroleum products is estimated to grow at a CARG of 5.8% and is expected to be 104.8 MT in 2002. This does not include liquid-fuel requirement for power generation, which has been estimated at 7.7 MT for the period 1992–97 by the Central Electricity Authority.

The GDP growth rate for the Ninth and Tenth Plan periods is assumed as 6.5% while the cumulative average growth rates of petroleum product demand for the same periods are estimated at 6.9% and 6.3%, respectively, by the Sub-Group on Demand Projections.

The demand of 105 MT a year in 2001/02 has been used for planning supplies for the Ninth Plan period (Planning Commission 1999). Due to the large quantum of demand, the percentage self-reliance is expected to decline from 38% in 1997/98 to 33% by the year 2001/02 with an estimated crude oil and product import of 83 MT (Table III).

The oil import dependence is expected to reduce from 39% in 1997/98 to 33% in 2001/02. The import dependence could be further reduced by:

- accelerated exploration, especially offshore, with improved reservoir management;
- rationalization of oil prices,
- acquisition of acreage and equity oil in other countries; and
- creation of adequate refining capacity, which has been achieved to a large extent already.

Planning supplies for the Ninth Plan period would require an investment of 1240 billion rupees. This volume of investment, however, exceeds the capacity for resource mobilization by the government and public sector. Hence, private sector participation will have to be enhanced along with the phased introduction of a rational market-determined pricing mechanism.

Table III Demand, production, and import of crude and petroleum products (million tonnes)

Year	Product demand[1]	Refining capacity	Crude oil processing: Total	Crude oil processing: Indigenous	Crude oil processing: Imported	Refined products: Production	Refined products: Net imports	Total imports	Self reliance[2] (%)
1997/98	83.73	61.55	65.1	34.4	30.7	63.4	28.0	58.7	39
1998/99	88.56	67.55	69.5	35.6	33.9	67.7	30.4	34.3	38
1999/2000	93.67	104.95	76.3	36.5	39.8	73.2	32.0	67.3	37
2000/01	99.07	107.95	100.0	37.1	62.9	95.2	19.4	82.3	35
2001/02	104.80	113.95	124.7	36.9	78.0	119.2	4.8	82.8	33

[1] demand for petroleum products does not equal production and imports because of variation in inventories

[2] self reliance = domestic crude production - six per cent refinery losses/petroleum product demand

Source Planning Commission (1997a, 1999)

The long-term demand forecasts are given in Table IV.

Table IV Long-term demand forecasts

Forecast	2001/02	2006/07
Demand (million tonnes)	104.80	155.30
Compounded annual rate of growth (%)	4.59	6.6

Source OCC (1996), Planning Commission (1999)

Natural gas

The gas allocations for the Ninth Plan period were made by the Inter-Ministerial Gas Linkage Committee. The Committee, besides following the policy of greater gas usage in the priority sectors, namely, fertilizer and power, also ensured maximization of domestic gas utilization by committing gas to other categories of end users, such as industry, on firm demand as well as on fall-back basis (Planning Commission 1997b).

In the short term, no fresh gas commitments are being made due to constraints on supply and, therefore, the allocation for natural gas remains constant in the latter part of the Ninth Plan (Table V).

During the Ninth Plan period, gas would be available from the oil and gas fields of the ONGC (Oil and Natural Gas Corporation), the OIL (Oil India Limited), as well as from the discovered oil and gas fields being developed as projects. In addition, gas imports in the form of pipe gas/LNG (liquefied natural gas) are being considered.

Table VI gives the unconstrained demand till 2009/10 as estimated by the Expert Group constituted by the Ministry of Petroleum and Natural Gas. These estimates are based on the price of gas (domestic and imported) as against fuel alternatives, availability of transportation infrastructure, etc.

The increase in the demand growth rate during the Ninth Plan period can be attributed to the planned capacity addition in the power, fertilizer, and industrial sectors, supply constraints on primary energy sources, and environmental advantages of natural gas. However, the effective gas demand may be significantly lower than the projected values.

In order to enhance supplies, LNG imports as well as unconventional gas resources like coal-bed

Table V Short-term allocations (constrained) and availability projections for natural gas (million cubic metres per day)

Forecast	1997/98	1998/99	1999/2000	2000/01	2001/02
Allocation	76.64	79.70	82.68	82.68	82.68
Availability	58.83	63.22	63.69	64.85	67.25

Source Planning Commission (1997b)

Table VI Long-term demand (unconstrained) and supply forecasts (million cubic metres per day)

Forecast	2004/05	2009/10
Demand	188	283
Supply	68	68
Compounded annual rate of growth for demand (%)	4.304	7.05
Deficit	120	215

Source Planning Commission (1997b)

methane, of gas hydrates, and in-situ coal are being considered.

Power

The Fifteenth Electric Power Survey projects power demand for two time horizons, the short-term forecasts up to 2001/02 and long-term forecasts up to 2011/12 (MoP 1995). The short-term forecast is based on a detailed analysis of the consuming sectors, inter alia taking into account the production targets indicated for each industry, the trends in consumption pattern, etc., and making due allowances for restrictions in power supply experienced in the past (Table VII).

The long-term forecast (up to 2011/12) is made by extrapolating the overall power demand based on macro considerations taking into account the possibility of reduction in growth rates with time due to an enlarging base (Table VII). Peak loads were estimated after applying suitable annual load factors in the case of states and union territories and suitable annual diversity factors in case of regions. The forecasts are only indicative, and will have to be reviewed from time to time in light of perspective planning on a longer time horizon.

The *Sixteenth Electric Power Survey*, however, scales down the power requriements by 10%, in view of the fact that the government does not expect an economic recovery till the end of the Tenth Plan Period. The growth of power demand during the terminal year of the Tenth Plan has been scaled down to 6.13% from 6.5%. According to the preliminary figures available from the *Sixteenth Electric Power Survey*, the peak demand at the end of the Ninth and Tenth Plan periods is 84 500 MW and 118 000 MW, respectively. The actual energy requirement is also projected to be lower at 535 GWh and 700 GWh compared to the earlier figures of 570 GWh and 782 GWh, respectively.

The power supply position at the beginning of the Ninth Plan period was one of shortages. With a planned capacity addition of 40 245 MW during the Ninth Plan period (Table VIII) and the demand as projected by the *Fifteenth Electric Power Survey*, the reliability in terms of LoLP (loss of load probability) is estimated to vary between 0.14% in the southern region and 19% in the northern and western regions, which are much higher than the norm of 0.01%–0.001% in the developed countries.

According to the mid-term review of the Ninth Plan, it is estimated that only 70% of the targeted capacity addition (28 115 MW) will be achieved by 2002. While the central sector is expected to add 9760 MW as against the planned addition

Table VII Long-term demand-supply forecasts

Year	*Peak load (GW)*	*CARG[1] for peak load (%)*	*Installed capacity (GW)*	*Peaking capability (GW)[2]*	*Deficit (GW)*
2001/02	95.76	5.3	126.04	88.92	–6.84
2006/07	130.94	6.5	181.10	129.82	–1.12
2011/12	176.65	6.5	242.00	146.67	–29.98

[1] compounded annual rate of growth

[2] peaking capability has been calculated by multiplying the installed capacities by the peaking capability factor, which is 72% for thermal, 75% for nuclear, and 86.5% for hydro capacity for new capacity additions and 60.3% for thermal and nuclear and 91.5% for hydro capacity for the existing capacity

Source MoP (1995), CEA (1998), Planning Commission (1997c)

Table VIII Planned capacity additions (MW)

Plan period	*Hydro*	*Thermal (coal and gas)*	*Thermal (liquid fuel)*	*Nuclear*	*Total*
1997-2002	9819.7	23545.5	6000	880	40245.2
2002-07*	8550.0	46711.0	–	1706	56987.0
2007-12*	27809.0	21074.0	5942	4174	58999.0

*based on the case with unconstrained supply of coal and critical review of hydro projects

Source CEA (1998)

of 11 999 MW, the state sector is expected to add 9860 MW, which is close to the targeted addition of 10 748 MW. The private sector is expected to fall short of the targeted addition of 17 588 MW as it is expected to achieve only 8495 MW. The performance, however, is expected to be better than that during the Eighth Plan period. Therefore, to keep the LoLP between two and five per cent at the end of the Tenth Plan period, a much higher capacity addition will be required.

The Planwise fuel requirements are provided in Table IX. Of the total requirement of 276.5 MT of indigenous coal, the power sector is expected to receive only 262 MT during the Ninth Plan period. This shortfall in coal supply may be attributed to constraints on production or transport infrastructure.

Table IX Fuel requirements for power generation

Fuel	1997-2002	2002-07*	2007-12*
Coal (indigenous) (MT)	276.5	418.8	487.0
Coal (imported) (MT)	3.3	0.0	28.2
Lignite (MT)	18.7	47.1	49.8
Liquid fuel (MT)	7.7	0.6	4.2
LNG (BCM)	2.9	0.4	1.2
Natural gas (BCM)	10.7	12.2	12.2
Nuclear Fuel (Mkg)	0.4	0.6	1.2

MT - million tonnes; BCM - billion cubic metres; Mkg - million kilograms

* results of case with unconstrained supply of coal and critical review of hydro projects

Source CEA (1998)

The Ministry of Power has allocated 18.5 MT of naphtha and furnace oil for a capacity of 12 000 MW. The Ninth Plan envisages a total capacity addition of 6000 MW based on liquid fuels. The fuel requirements, however, are expected to change with lower than targeted capacity additions by the end of the Ninth Plan period.

The planned capacity additions during the Tenth Plan period provided in Table IX are based on the premise that there are no constraints on the availability of coal, transportation of fuel, and transmission of power. In this case, however, hydro power plants, which could yield benefits, are critically evaluated based upon their status and preparedness. The coal requirement estimated at 419 MT is higher than that in the Ninth Plan period on account of capacity additions from mega power projects in the eastern region. The requirement for liquid fuels is much lower for the Tenth Plan period as the PLF (plant load factor) of plants based on liquid fuels is expected to be much lower than that in the Ninth Plan period (Table IX). Due to shortages for meeting the peak and energy demand, the liquid-fuel-based plants are expected to operate at higher PLFs during the Ninth Plan, while liquid-fuel-based plants are expected to meet only the peak demand during the Tenth Plan period.

When compared with the corresponding case for the Tenth Plan period, the capacity addition during the Eleventh Plan period is estimated at 59 000 MW with a requirement of 565 MT of coal. Some of the factors that are likely to impact the future capacity additions and fuel requirements for power generation are listed below.

- Constraints on the availability of coal leading to the development of more liquid-fuel-based plants
- Limited availability of coal resulting in higher PLFs for liquid-fuel-based power generation and hence greater requirement for liquid fuels
- Development of LNG pipelines, thereby replacing the demand for liquid fuels by LNG
- Development of coastal shipping resulting in the replacement of imported coal by indigenous coal
- Higher production levels for indigenous coal and better transportation infrastructure resulting in the replacement of imported coal and liquid fuels by indigenous coal
- Environmental constraints in setting up of hydroelectric projects will result in a shift towards thermal and nuclear projects
- Rationalization of fuel prices
- Development of power generation capacity based on non-conventional energy sources.

Environmental impacts

Projections of emissions of particulate matter and oxides of nitrogen, carbon, and sulphur using the TEESE (TERI Energy Economy Simulation and Evaluation) Model are given in Table X. These projections are not based on the energy demand forecasts provided in the earlier sections. An increasing trend in the emission levels is observed and this could be curtailed by enhancing energy efficiency in the transport sector, through fuel substitution, better technologies, and increasing the share of railways. In the industrial sector, however, fuel substi-

Table X Emissions of various pollutants under the business-as-usual scenario (million tonnes)

Pollutants	*1996*	*2001*	*2006*	*2011*
Carbon monoxide	16.16	17.90	19.60	22.00
Suspended particulate matter	0.30	259.10	338.00	434.00
Oxides of nitrogen	1.34	1.75	2.19	2.82
Oxides of sulphur	0.05	0.09	0.13	0.16

Source TERI / UNEP (1995)

tution is restricted by the choice of technology and raw materials used.

Even though India is not committed to reducing carbon dioxide emission levels, it is important to take stock of the GHG (greenhouse gas) inventory due to rising international pressures. TERI has made projections on GHG emissions for the energy sector up to 2020 using the MARKAL model at a 12% discount rate (Table XI). The projected carbon dioxide emissions are only from fossil fuels and do not consider land-use change or the forestry sector.

Table XI Carbon dioxide emissions projection in baseline scenario (Tg of carbon)

Projections	*1990*	*2000*	*2010*	*2020*	*Total (1990-2020)*
Coal	327	608	895	1336	27338
Oil	178	309	553	777	15690
Gas	27	56	107	198	3324
Baseline emissions	532	973	1555	2308	46352
Compounded annual rate of growth (%)	–	6.223	4.800	4.0281	16.057

Source TERI (1998)

The typical mitigation options of GHGs that have been assessed provide long-run opportunities in the energy sector. These include, improvements in energy efficiency through currently employed technologies and through the introduction of advanced technologies that are either more efficient or are based on renewable energy sources.

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ENERGY DEMAND

Agriculture

Introduction

In India, agriculture is the largest sector of economic activity. According to the 1991 census, 68% of the workforce was employed in this sector. Realizing its importance, the Ninth Five-Year Plan (1997–2002) has accorded priority to agriculture and rural development with a view to generating adequate productive employment and eradicating poverty. The Executive Summary to this Plan suggests development of agro-based industries to harness growth and distributive potential of agriculture. The share of agricultural sector to the GDP (gross domestic product) has decreased from 50% in 1950/51 to 27.6% in 1996/97 (at 1980/81 prices) (Table 1). During the Eighth Plan, agricultural production increased by about 3.9% a year, with the foodgrain output growing at 3% a year.

The total foodgrain production in India has increased from 51 MT (million tonnes) in 1950/51 to 191 MT in 1994/95. In 1995/96, the foodgrain production dropped to 180 MT, recording a decline of nearly 11 MT only to register an increase to 199 MT in 1996/97. However, the foodgrain output fell by 7 MT in 1997/98, but recovered marginally to 195.2 MT in 1998/99 (Figure 1).

According to the Executive Summary to the Ninth Five-Year Plan, the foodgrain production is projected to increase from 199 MT in 1996/97 to 304 MT in 2011/12, whereas consumption is likely to increase from 195 MT in 1996/97 to 298 MT in 2011/12. The growth rate of yield is expected to be 2.9% a year over the entire Ninth Plan perspective period.

According to the information furnished by the Ministry of Agriculture, the agricultural production during 1996/97 registered about 6% growth, mainly due to the steep increase in the production of wheat (10%), coarse cereals (16%), pulses (10%), oilseeds (12%), and cotton (9%). Rice, wheat, and coarse foodgrains like maize, bajra, and jowar are the major crops of India occupying more than 90% of the area under foodgrains and 82% of the net cultivated area. The share of rice and wheat in total foodgrain production increased from 53% in 1950 to 76% in 1994. Rice forms 43% of the total foodgrain production in India and is cultivated in 43 million hectares, which is about 30% of the net cultivated area (Tables 3 and 4). The demand for rice is expected to increase to 95–100 MT in the next five years and to 120–125 MT a decade beyond. This demand can be met if the productivity of crops increases from the present level of 1.9 tonnes per hectare to 2.47 tonnes per hectare and 3.5 tonnes per hectare by 2000 and 2010, respectively, with least damage to the natural resource base.

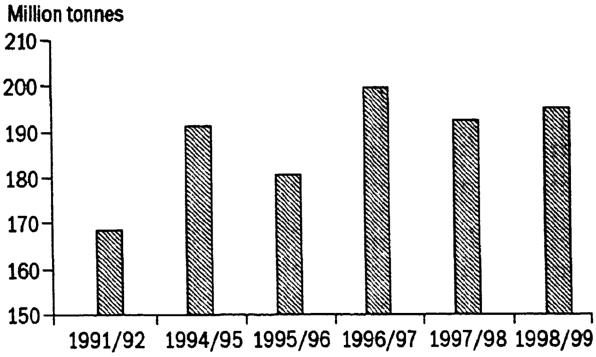


Figure 1 Production of foodgrains

Source MoF (1999)

Wheat accounts for one-third of the total foodgrain production. The high-yielding varieties now cover about 87% of the area under wheat cultivation and the area under wheat cultivation is increasing at the rate of 1.7% a year compared to 0.5% a year for rice. The annual production of 60 MT and a low growth rate of wheat in the past seven years (1.5%)

indicate that the wheat yield plateau has been reached. The production of high-yielding varieties and also the irrigation coverage have almost reached the saturation level in the wheat-growing belt in India. Further increase in production can only be expected through consumption and efficient use of fertilizers. The demand for wheat is expected to increase to 95 MT by 2020.

The progress in Indian agriculture can be attributed to (1) the development of improved agricultural techniques; (2) the development of an efficient input production and delivery system; (3) the progress being made in agrarian reforms; and (4) the development of rural infrastructure, input and output pricing policies, and marketing arrangements.

Agricultural inputs

Land

Out of the total geographical area of 329 million hectares, only 305 million hectares is the reporting area, the rest being unadministered for various reasons (Table 2). Of this reporting area, about 21 million hectares is for housing, industries, and other non-agricultural purposes; 19.5 million hectares is snowbound and remote, leaving only 264 million hectares for agriculture, forestry, pasture, and other biomass production. Since 1950, about 27 million hectares have been added to the forest area mostly through taking over private forest lands from *zamindars* (the land owners). The reporting area also got increased in the process. The net area sown increased from 119 million hectares in 1950/51 to 143 million hectares in 1994/95, mostly through reclamation of old fallow and cultivable wastelands and diversion of groves. As per the information given in the Executive Summary to the Ninth Five-Year Plan, the net area sown is expected to remain more or less constant at 143 million hectares throughout the perspective period. The cropping intensity is projected to rise from 134.2% in 1996/97 to 150.35% in 2011/12.

Water

The distribution of rainfall in India is highly erratic in space and time, but the annual average rainfall in the country is 1150 mm, of which 73% is received through the south-west monsoon. The country has been receiving normal rainfall for the sixth year in succession (since 1993), as indicated by the proportion of actual rainfall as a percentage to normal rainfall. With just small proportion of the cultivated area being irrigated, agriculture in India depends on monsoons to a great extent.

Irrigation

The area under irrigation has increased over time. The development in irrigation potential is largely due to the efforts of the government in developing irrigation facilities through major, medium, and minor irrigation projects. Till 1992, 120 major and medium irrigation projects had been completed, and in the Eighth Five-Year Plan (1992–97), there were 158 projects ongoing. It is estimated that the country has an ultimate irrigation potential of 140 million hectares comprising 58.5 million hectares by major and medium irrigation schemes, about 17 million hectares by minor surface water schemes, and about 64.5 million hectares by groundwater.

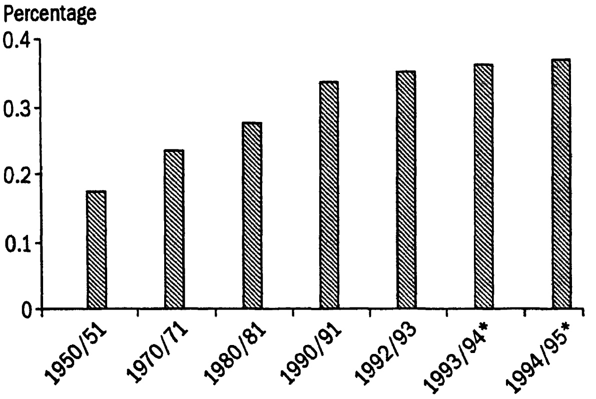
The irrigation facilities have increased from 23 million hectares to about 85 million hectares in 1994, comprising 32 million hectares under major and medium irrigation projects, and 53 million hectares under minor irrigation projects. At the end of 1994, the utilization was 78 million hectares. This leaves a gap of 7 million hectares of underutilized potential. This gap is due to delays involved in the development of on-farm works like construction of field channels, land levelling, adoption of *warabandi* system, and also the time taken by farmers in switching from dry farming to irrigated agriculture.

Net irrigated area has increased from nearly 31.11 million hectares in 1970/71 to 53 million hectares in 1994/95 (Table 10). This represents an increase from 22.1% to 37.1%, where the percentage is computed as irrigated area as a percentage of the net sown area (Figure 2).

Indirect inputs

High-yielding variety seeds

Good-quality certified seeds are the basic and crucial inputs for attaining sustained growth in agricultural production as they act as the catalyst for making other inputs cost-effective. The total area under high-yielding varieties of different crops has increased from 15.38 million hectares in 1970/71 to 72.11 million hectares in 1995/96 (Table 5). As a result of this, the use of certified/quality seeds by the farmers has increased from 0.2 MT in 1970/71 to 0.70 MT in 1996/97. The high-yielding varieties are also highly susceptible to pests and diseases. This



* provisional

Figure 2 Status of irrigation in India (irrigated area as a percentage of net area sown)
Source MoA (1998)

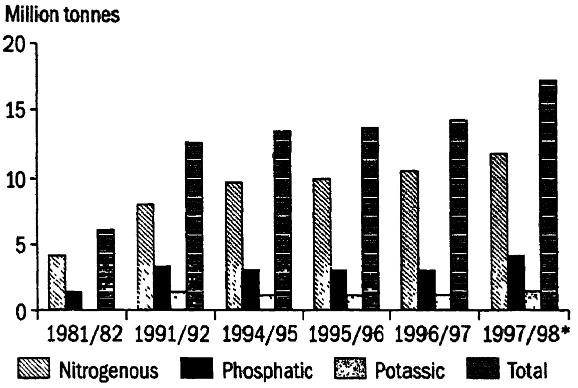
means that these crops need constant care and plant protection measures.

Fertilizer use

India is the fourth largest fertilizer consumer in the world. The consumption has increased from 0.29 MT in 1960/61 to 14.31 MT in 1996/97 (Table 11). Prior to 1966, most of the cultivated area in India was under traditional varieties, which are low-yielding and less responsive to the addition of nutrients. However, with the introduction of dwarf high-yielding varieties in 1966, which are highly responsive to the addition of nutrients, the fertilizer consumption increased steadily thereafter.

The chemical fertilizer consumption was 80 kg/ha in 1994/95, but would stand at 185.81 kg/ha in 2011/12. Since such a level of chemical fertilizer intensity would not be suitable from the environmental point of view, the replacement of chemical fertilizers with biofertilizers is essential. The Ninth Plan, as such, encourages greater use of biofertilizers and biotechnological research in this direction.

The consumption of fertilizers in gross cropped area in 1996/97 was 76.75 kg/ha. The increase in consumption has been three-fold, from 5.5 MT in 1980/81 to 14.3 MT in 1996/97. The consumption is anticipated to increase to 16.4 MT in 1997/98 (MoF 1998). Both nitrogenous and phosphatic fertilizers have registered an increase in consumption although the increase has been substantial in the case of nitrogenous fertilizers (0.4 MT between 1995/96 and 1996/97). The consumption of potassic fertilizers declined from the previous year (Figure 3). The ideal NPK (nitrogen, phosphorus, and potassium) ratio aggregated for the country as a whole is 4:2:1, but the all-India NPK ratio for 1998/99 stands at 8.3:3:1, thus biased in favour of nitrogenous fertilizers (MoF 1999).



* provisional

Figure 3 Consumption of fertilizers
Source MoA (1998)

Pesticides

Pesticides are chemicals that attack, repel, sterilize, stupify, or destroy any insect, fungus, bacterium, rodent, etc. In India, 133 pesticides have been registered on a regular basis, of which 34 pesticides are either banned or restricted in some other countries but are still in use in India (CPCB 1994). The promotion of IPM (integrated pest management) for all the crops and throughout the country would continue to remain the main thrust of plant protection activities during the Ninth Plan.

Indiscriminate use of toxic pesticides can adversely affect both human and animal health, besides poisoning and polluting air, water, and soil. Use of safer pesticides, including neem-based and biopesticides, is encouraged to manage pest problems. As a result of this, the consumption of pesticides (technical grade material) has come down from 75.89 thousand tonnes during 1988/89 to 56.11 thousand tonnes during 1996/97 (Table 12). The consumption of pesticides in each state is given in Table 13, which indicates that Andhra Pradesh has the maximum share of pesticide consumption (16.11%), followed by Uttar Pradesh (13.63%).

Energy use in agriculture

Land preparation and irrigation are the two major agricultural operations where energy is used. Agricultural productivity mainly depends on two resources, namely, land and energy (both direct and indirect). Since land is more or less a fixed resource, agricultural productivity has been related directly to the energy inputs. Agriculture is a seasonal industry, and, therefore, the demand for energy fluctuates throughout the year. In certain months of the year, agriculture demands more energy for crucial operations like sowing, transplantation, harvesting, and threshing on time.

Oil and electricity are extensively consumed in this sector. Although the quantum of energy consumed has increased in absolute terms for both oil and electricity, between 1970/71 and 1987/88, their relative share has remained constant, with 64% accounted for by oil and 36% by electricity (Table I).

A study undertaken by TERI (Tata Energy Research Institute), entitled *Agricultural energy requirements in India*, arrived at the national-level commercial energy estimates for two major crops, paddy and wheat, for 1985/86. In the study, data for Punjab have been used for projecting energy requirements at the national level.[1]

Table I Share of oil and electricity in the final commercial energy consumption in the agricultural sector (peta calories)

Year	*Oil*	*Electricity*	*Total*
1970/71	6.88 (64.15)	3.84 (35.85)	10.72 (100)
1975/76	14.23 (65.49)	7.5 (34.51)	21.73 (100)
1980/81	27.94 (69.16)	12.46 (30.84)	40.4 (100)
1984/85	39.65 (68.75)	18.03 (31.25)	57.68 (100)
1987/88	47.05 (64.44)	25.96 (35.56)	73.01 (100)

Note Figures in parentheses indicate percentages.
Source Planning Commission (1993)

It is clearly evident from Table II that land preparation and harvesting account for the bulk of diesel consumption whereas electricity is largely used for irrigation purposes. All activities put together, paddy and wheat consume approximately 1.55 MT of diesel, which is a little over 10% of the total diesel consumption in the country for 1985/86. The total electricity consumption is 21.13 TWh, which is approximately 90% of the reported electricity consumption by this sector.

Table II Estimated total energy consumption for wheat and paddy in 1985/86

Activity	*Energy source*	*Estimated consumption*	
		Wheat	*Paddy*
Land preparation	Diesel	0.32 MT	0.15 MT
Irrigation	Diesel	0.11 MT	0.24 MT
	Electricity	6.16 TWh	14.73 TWh
Harvesting, collection, and threshing	Diesel	0.43 MT	0.13 MT
	Electricity	0.24 TWh	–
All activities	Diesel	1.01 MT	0.54 MT
	Electricity	6.40 TWh	14.73 TWh

Source TERI (1988)

Land preparation

Traditionally human labour and livestock have been the main sources of energy for Indian agriculture, and they still continue to be so despite substantial mechanization process taking place in this sector. Farm operations like digging, transplantation, weeding, harvesting, and paddy threshing are largely performed manually. India has about 200 million agricultural workers providing 43 000 TJ (tera joules) of human energy and 80 million draught animals providing 81 000 TJ of animal energy. Together they provide about 0.298 kW/ha of farm power. The DAP (draught animal power), by and large, continues to be a major power source for field operations. During the 1970s and 1980s, the Indian agriculture witnessed a rapid rise in the use of modern farm equipment. Table III shows the changes in the number of mechanized and traditional means of cultivation.

The mechanization process in the agricultural sector accelerated with the introduction of high-yielding variety seeds by the government in the 1960s. Table III shows that in 1971/72, there were only 75 000 tractors in the country. By 1981/82, the number rose to half a million, and in 1991/92, the number of tractors was estimated at 1.4 million. Also, in 1971/72, about five million pumps were in use. Each of the following decades saw an addition of five million. The rapid rise in the number

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[1] Using data for Punjab may overestimate commercial energy requirements for other states. However, as the report argues, this information is still useful to look at the requirements of diesel and electricity in other states to attain the same technology levels as Punjab.

Table III. Mechanized versus traditional cultivation

Year	*Tractor (thousands)*	*Power tiller (thousands)*	*Pumps (electric and diesel) (million)*	*Working bovine stock (million)*
1971/72	75	–	5	81
1981/82	486	249	11	73
1991/92	1363	513	16	13

Source GoI (1997)

of tractors during the 1970s was accompanied by a fall in the working bovine stock, from 81 million in 1971/72 to 73 million in 1981/82. However, there has been no change in the working bovine stock in the subsequent decade.

The mechanization of agriculture has progressed at disparate rates in different states of the country. In 1991/92, Punjab, Haryana, and Uttar Pradesh recorded the highest tractor-to-operated area ratios (Table 16). At the national level, the working bovine stock per 100 hectares fell with the rise in tractor-to-operated area ratio during the past two decades (1971–91). However, Bihar stands out as a glaring exception, in which both the ratios have been rising steadily since 1971/72. In Haryana and Gujarat, the number of working bovines per 100 hectares rose during 1970s, despite a rise in the number of tractors per 10 000 hectares.

It is estimated that more than 55% of land is cultivated by DAP (with a command area of 2 hectares per pair). Paddy, which is grown in 23% of the total cropped area (1992/93), uses 35.6% of the total DAP. The use of animal energy per hectare for jute, potato, onion, and paddy crops is comparatively high. These crops are largely grown in states with higher DAP density and lower levels of mechanization. However, the share of DAP in the total farm power is declining.

The share of human energy in the total farm power has decreased from 35% in 1950/51 to 8% in 1995/96. Similarly, an analysis of the use of DAP in crop production for the period 1971/72 to 1990/91 revealed that the average use of animal energy per hectare has come down from 159 animal pair per hour per hectare to 109 animal pair per hour per hectare, registering a decline of 1.5% a year. The total power availability from DAP in 1995/96 was estimated at 16.8 million kW. This formed 12.3% of the total farm power consumption in 1995/96. The share of DAP in agriculture has decreased from 55% in 1950/51 to 12% in 1995/96. India with limited landmass and increasing human population cannot afford to have more draught animals. For a desirable level of agricultural activity (200% cropping intensity), the farm power requirement is estimated at 0.746 kW/ha.

Human resource is surplus, leading to unemployment problems during off-season. However, in peak periods, DAP is not enough to cope with the heavy loads. Therefore, the deficit in farm energy availability has to be met from mechanized sources. To a considerable extent, DAP has been supplemented by tractors, power tillers, diesel engines, and electric motors. The use of tractors has increased at a compound growth rate of more than 13% a year, which may stabilize around 10% by the next decade. With an estimated total tractor population of 1.8 million, the country has a potential to cover 16%–17% of the cultivated area (15–16 hectares operational area per tractor).

In spite of the phenomenal growth in the number of tractors in the past two decades, the Indian agriculture continues to depend to a great extent (about 25%) on animate energy for various operations. Further, human labour accounts for almost eight per cent of the energy used for farm operations. The relative share of electricity and diesel power as against human and animal labour is shown in Figures 4 and 5 corresponding to 1950/51 and 1995/96.

Though farm mechanization is increasing, unfortunately, the yield increases do not reflect the

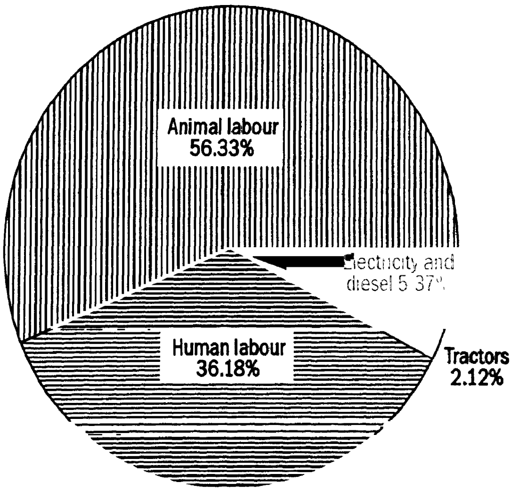

Figure 4 Energy consumption in agriculture (1950/51)

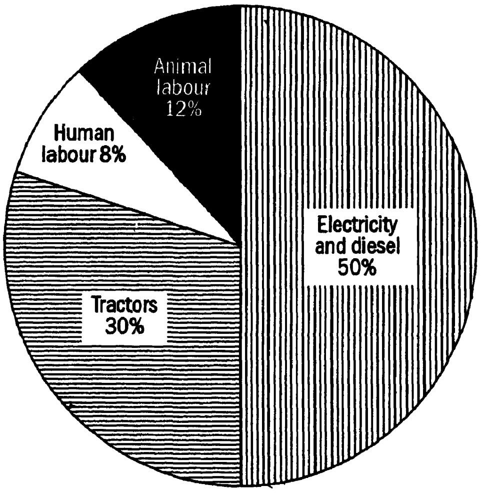

Figure 5 energy consumption in agriculture (1995/96)

proper use of energy in Indian agriculture. The output-to-input ratio has gone down considerably over the years. There is further distortion of data as energy consumption is measured merely in terms of the number of pumpsets energized.

Irrigation is largely done using diesel and electrical energy. The number of electric pumps has increased from 1.6 million in 1970/71 to 10.3 million during 1993/94. Likewise, the number of diesel pumps has increased from 1.5 million to 4.9 million during the same period. Consequently, the share of the farm sector in electrical energy consumption has increased from a mere 3.9% in 1950/51 to 28.7% in 1992/93. Diesel consumption by farm sector is little over 10% of the total diesel consumption. Electricity and diesel power contributed almost 50% of the total farm power consumed for irrigation in 1995/96. The decision of most of the state governments to have a subsidized flat-rate tariff on electric pumpsets based on horsepower rating led to an increase in the number of irrigation pumpsets and their utilization.

Electricity use in agriculture

Electricity is an essential input for agricultural development. The availability of farm power per unit area (kWh/ha) has been considered as one of the parameters of expressing the level of mechanization. The total power availability from all the sources has increased from 0.18 kWh/ha in 1950/51 to 0.7 kWh/ha in 1995/96 at a compound annual growth rate of 3.06%. The total electricity consumption has increased in absolute terms from 15 201 GWh to 58 788 GWh during the period 1981–91, and further to 79 301 GWh in 1994/95 (Table IV). The share of agriculture to total electricity use also increased from nearly 17% in 1981/82 to 30.5% in 1994/95. The share increased slightly to 30.9% in 1995/96, but fell to 29.6% in 1996/97.

Table IV All-India consumption of electricity

Year	*For agriculture consumption (million kWh)*	*Total consumption (million kWh)*	*Share of agriculture consumption to total consumption (percentage)*
1981/82	15201	90245	16.84
1991/92	58557	207645	28.20
1992/93	63328	220674	28.70
1993/94	70699	238569	29.64
1994/95	79301	259630	30.54

Source MoA (1997)

In 1997/98, the average electricity tariff for agriculture was only 22 paise/kWh, while that for industry was 293 paise/kWh. With most of the state governments either refusing to raise the tariff for the farm sector even nominally, the power subsidy to agriculture has gone up sharply in recent years. Effective subsidy for agricultural consumers has been increasing steadily from 73.34 billion rupees in 1992/93 to 174.91 billion rupees in 1997/98. This has increased the use of electricity as compared to diesel. The annual rate of increase in the availability of farm power is 0.03 kWh/ha. The share of mechanical power in total farm power has increased from 3.6% in 1950/51 to 80% in 1995/96. The government has been adopting deliberate policies in the use of electricity such as supply of cheap electricity to farmers and pumpset energization.

Energization of pumpsets used in irrigation

The groundwater sources contributed nearly 53% of the total area irrigated in 1992/93. There has been a dramatic increase in the utilization of groundwater since the 1960s due to rural electrification and a substantial increase in the number of energized pumpsets. The groundwater resource is getting depleted due to increased levels of extraction.

The surface water sources like rivers, canals, tanks, and rivulets have also been affected considerably due to degradation and siltation of river beds. The Ninth Plan has set a target of 67% for energization of pumpsets.

A comparison of the estimated consumption figures and those actually achieved during 1994/95 indicates that in the agricultural sector, the consumption has exceeded by five per cent over the figures forecast. In the industrial sector, the consumption has fallen short by about 10% (MoP 1995). If this trend is not reversed, a major percentage of power generated from new power stations during the Ninth Five-Year Plan may well go towards meeting the requirements of T&D losses, agricultural consumption, and pilferage of electricity.

The usage of energy has increased manifold, but over a very small area with little yield increments. Therefore, there is no doubt that with the groundwater table going down, the electricity consumption per kilowatt-hour should increase. However, such consumption should be properly metered and not merely estimated to depict the actual situation for remedial action. The future lies in drastic energy savings while maintaining yields by water conservation and by shifting to energy-efficient tilling and fertilizer operations.

The Ninth Five-Year Plan (1997/98 to 2002/03): focus and strategy

The Ninth Plan target is to achieve a growth rate of about 4.5% a year in agricultural output and production of 234 MT of foodgrains by 2001/02. Agricultural development would be centred on achieving the objectives of sustainability of employment generation, food and nutrition security, equity, and poverty alleviation.

The various targets to be achieved through regionally differentiated strategies based on agroclimatic regional planning, which takes into account agronomic, climatic, and environmental conditions, are as follows.

- *High productivity zone.* The high-productivity zones in the north-western regions to promote diversification and high-value crops and to strengthen linkages with agro-processing industries and exports.
- *Low productivity–high potential zone.* Eastern region with abundant water to exploit the productivity potential through flood control, drainage management, improvement of irrigation facilities, and improved input delivery systems.
- *Low productivity zone.* Water-scarce peninsular region, including Rajasthan, to focus on efficient water harvesting and conservation methods and technologies based on watershed approach and appropriate farming system.
- *Ecologically fragile regions.* Ecologically fragile regions, including Himalayan and desert areas, to concentrate on eco-friendly agriculture.

For achieving the objective of sustainable agricultural development, greater emphasis would be laid on (1) conservation of land, water, and biological resources; (2) development of rural infrastructure; (3) development of rain-fed agriculture; (4) development of minor irrigation; (5) timely and adequate availability of inputs; (6) increasing flow of credit; (7) enhancing public sector investment; (8) enhancing support for research; (9) effective transfer of technology; and (10) marketing infrastructure support and export promotion.

The National Agricultural Policy, which is in the stage of finalization, would focus on the optimal use of land, water, and genetic resources in a sustainable manner. It would include leasing of land, consolidation of land, improvement of rural marketing infrastructure, and use of 80 million hectares of wasteland and community lands for agro-forestry.

The Ninth Plan would also focus on social objectives of recognition of women's rights in land, protection of tribal's rights in land, and raising the land productivity in eastern India.

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Table 1

Contribution (million rupees) of agricultural sector to GDP (gross domestic product) and NDP (net domestic product) at current and constant prices: 1970/71 to 1996/97

Prices	*1970/71*	*1980/81*	*1986/87*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96* *	*1996/97* †
Total GDP										
Current prices	171639	424660	744050	1351620	1592990	1779100	2063220	2391590	2556130	2871320
Constant prices	366230	424660	489950	609910	593980	633270	657620	692060	668630	723620
Total NDP										
Current prices	161900	400560	694460	1272590	1498240	1669490	1943160	2253960	2395820	2687290
Constant prices	345450	400560	461170	577730	560320	597810	620930	653020	626650	678710

* provisional

† quick estimates by the Central Statistical Organization

Sources

1. MoPPI National Accounts Statistics (various issues). New Delhi: Central Statistical Organization, Department of Statistics. Ministry of Planning and Programme Implementation.
2. CSO. 1998. Estimates of national income, consumption expenditure, savings and capital formation, 1996/97. New Delhi: Central Statistical Organization.
   (For 1995/96 revised figures and for 1996/97 estimates)

For more details, please see TEDDY ONLINE+ [Section: Agriculture (agriculture and national income)]

Table 2

Land-use classification (million hectares). 1970/71 to 1994/95

Items	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94 **	*1994/95 **	*Reporting area (%) (1994/95)*
Geographical area	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7	—
Reporting area for land utilization	303.8	304.3	304.2	304.7	304.9	304.9	304.9	304.9	304.9	100.0
Forests	63.9	66.4	67.5	67.1	67.8	67.9	68.0	68.3	68.4	22.4
Not available for cultivation	44.6	39.5	39.6	40.7	40.5	40.7	40.9	41.0	41.3	13.6
Area under non-agricultural uses	16.5	17.4	19.7	20.6	21.1	21.5	21.9	22.2	22.5	7.4
Barren and unculturable land	28.2	22.1	20.0	20.1	19.4	19.3	19.0	18.7	18.8	6.2
Other uncultivated land excluding fallow land	35.1	34.2	32.3	31.1	30.2	30.1	29.4	29.1	29.1	9.6
Permanent pastures and other grazing lands	13.3	12.6	11.9	11.8	11.4	11.3	11.1	11.0	11.2	3.7
Land under miscellaneous tree crops and groves, not included in net area sown	4.3	4.0	3.6	3.6	3.8	3.8	3.8	3.7	3.6	1.2
Culturable wasteland	17.5	17.6	16.7	15.7	15.0	15.0	14.6	14.4	14.2	4.7
Fallow lands	19.9	22.0	24.8	25.0	23.4	24.6	23.8	24.0	23.3	7.6
Fallow land other than current fallows	8.8	9.5	9.9	10.1	9.7	9.9	9.7	9.6	9.8	3.2
Current fallows	11.1	12.5	14.8	14.9	13.7	14.7	14.2	14.4	13.5	4.4
Net area sown	140.3	142.2	140.0	140.9	143.0	141.6	142.7	142.4	142.8	46.8
Total cropped area (gross cropped area)	165.8	163.9	172.6	178.5	185.7	182.2	185.7	186.6	188.2	—
Area sown more than once	25.5	21.7	32.6	37.6	42.7	40.6	43.0	44.2	45.3	—
Cropping intensity (%)	118.2	115.2	123.3	126.7	129.9	128.7	130.1	134.0	131.7	—
Net irrigated area	31.1	33.7	38.7	41.9	47.8	49.9	50.3	51.3	53.0	—
Gross irrigated area	38.2	41.7	49.7	54.3	62.5	65.7	66.8	68.3	70.6	—

* provisional

Note
Cropping intensity is obtained by dividing the gross cropped area by the net area sown.

Source
MoA. Agricultural Statistics at a Glance (various issues) New Delhi. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture

For more details, please see TEDDY ONLINE+ [Section: Agriculture (land-related statistics)]

Table 3

Area (million hectares) under principal crops: 1970/71 to 1997/98

Crops	1970/71	1975/76	1980/81	1985/86	1990/91	1994/95	1995/96	1996/97	1997/98 *
Rice	37.6	39.5	40.2	41.1	42.7	42.8	42.8	43.3	43.4
Wheat	18.2	20.5	22.3	23.0	24.2	25.7	25.0	25.9	26.7
Pulses	22.5	24.5	22.5	24.4	24.7	23.0	22.3	23.3	22.8
Foodgrains	124.3	128.2	126.7	128.0	127.8	123.7	121.0	123.5	124.0
Cotton	7.6	7.4	7.8	7.5	7.4	7.9	9.0	9.1	8.9
Jute and mesta	1.1	0.9	1.3	1.5	1.0	0.9	0.9	1.1	1.1
Sugarcane	2.6	2.8	2.7	2.8	3.7	3.9	4.1	4.2	4.0
Tobacco	0.5	0.4	0.5	0.4	0.4	0.4	—	0.4	—
Oilseeds	16.6	16.9	17.6	19.0	24.2	25.3	26.0	26.8	26.2
Gross cropped area	165.8	171.3	172.6	178.5	185.7	188.2	—	7.0	—

* provisional

Sources
1 MoA. March 1998 Agricultural Statistics at a Glance New Delhi Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture
2 MoF 1999 Economic Survey 1998/99 New Delhi Ministry of Finance

For more details, please see TEDDY ONLINE+ (Section: Agriculture (area, yield, and production))

Table 4

Production (million tonnes) and yield (kg/ha) of principal crops. 1975/76 to 1996/97

Crops	1975/76		1980/81		1985/86		1990/91		1994/95		1995/96		1996/97	
	Production	Yield	Production	Yield	Production	Yield	Production	Yield	Production	Yield	Production	Yield	Production	Yield
Rice	48.7	1235	53.6	1336	63.8	1552	74.3	1740	81.8	1911	77.0	1797	81.3	1879
Wheat	28.8	1410	36.3	1630	47.1	2046	55.1	2281	65.8	2559	62.1	2483	69.3	2671
Pulses	13.0	533	10.6	473	13.4	547	14.3	578	14.1	610	12.3	552	14.5	623
Foodgrains	121.0	944	129.6	1023	150.4	1175	176.4	1380	191.5	1548	180.4	1491	199.3	1601
* Cotton	6.0	138	7.0	152	8.7	197	9.8	225	11.9	257	12.9	242	14.3	266
† Jute and mesta	5.9	1164	8.2	1130	12.7	1524	9.2	1634	9.1	1760	8.8	1712	11.0	1835
Sugarcane	140.6	50903	154.2	57844	170.7	59889	241.0	65395	275.5	71254	281.1	67787	277.3	66510
Tobacco	0.4	950	0.5	1065	0.4	1111	0.6	1353	0.6	1486	0.5	1356	0.6	1386
Oilseeds	10.6	627	9.4	532	10.8	570	18.6	771	21.3	843	22.1	851	25.0	931

* in bales, 1 bale is 170 kg
† in bales, 1 bale is 180 kg

Sources
1 MoA. 1998 Agricultural Statistics at a Glance pp 8–40 New Delhi. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture 140 pp.
2 MoF 1998 Economic Survey, 1997/98 New Delhi Ministry of Finance

For more details, please see TEDDY ONLINE+ (Section: Agriculture (area, yield, and production))

Table 5

Area (million hectares) under high-yielding varieties: 1970/71 to 1997/98

Crops	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1995/96*	*1996/97* *	*1997/98* *
Paddy								
Area	5.6	12.4	18.2	23.5	27.4	31.4	33.4	33.2
Percentage	14.9	31.5	45.4	57.1	64.2	—	—	—
Wheat								
Area	6.5	13.5	16.1	19.1	21.0	23.1	23.7	23.0
Percentage	35.5	65.8	72.3	82.9	86.9	—	—	—
Jowar								
Area	0.8	2.0	3.5	6.1	7.1	7.5	8.3	9.0
Percentage	4.6	12.2	22.1	38.5	49.4	—	—	—
Bajra								
Area	0.2	2.9	3.6	5.0	5.7	5.6	6.1	7.0
Percentage	1.6	25.0	30.9	46.7	54.4	—	—	—
Maize								
Area	0.5	1.1	1.6	1.8	2.6	3.6	3.8	3.6
Percentage	7.9	18.8	26.7	30.6	44.1	—	—	—

* anticipated achievement

Sources

1. FAI. 1998. Fertilizer Statistics, 1997/98. New Delhi: The Fertilizer Association of India.
2. MoF. 1996. Economic Survey, 1995/96. p. 137. New Delhi: Ministry of Finance. 296 pp.
3. MoF. 1999. Economic Survey, 1998/99. p. 137. S–22. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (area, yield, and production)]

Table 6

Progress of India's selected agricultural development programmes (million hectares): 1970/71 to 1997/98

Programme	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *
Area under high-yielding varieties												
Paddy	5.6	12.4	18.2	23.5	27.4	28.0	27.5	28.9	31.0	31.4	33.4	32.2
Wheat	6.5	13.5	16.1	19.1	21.0	20.5	21.7	22.0	23.2	23.1	23.7	23.0
Maize	0.5	1.1	1.6	1.8	2.6	2.8	2.6	2.7	3.4	3.6	3.8	3.6
Jowar	0.8	2.0	3.5	6.1	7.1	6.8	6.9	6.8	7.1	7.5	8.3	9.0
Bajra	2.0	2.9	3.7	5.0	5.7	5.4	5.6	5.1	5.4	5.5	6.1	7.0
Ragi	—	—	—	—	1.2	1.2	1.1	1.2	1.2	1.2	1.1	1.2
Total	**15.4**	**31.9**	**43.1**	**55.4**	**65.0**	**64.7**	**65.4**	**66.7**	**71.3**	**72.3**	**76.4**	**76.0**
† Soil conservation	13.4	20.0	24.4	30.5	34.9	35.7	36.5	37.3	38.2 ‡	39.3 ‡	—	—

* provisional
‡ cumulative level at the end of the year
† anticipated

Note
For 1992/93, the figures are cumulative targets for high-yielding varieties, irrigated area, and fertilizer consumption.

Source
MoF. 1999. Economic Survey, 1998/99. p. S-22. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (area, yield, and production)]

Table 7

Performance of total rainfall in a year

Year	*As percentage of normal rainfall*
1980	104
1985	93
1990	106
1991	91
1992	93
1993	100
1994	110
1995	100
1996	103
1997	102
1998	106

Source

MoF 1999. Economic Survey 1998/99 New Delhi Ministry of Finance.

Table 8

Development of irrigation potential (million hectares) during Plan periods

Item	*First Plan (1951–56)*	*Fourth Plan (1969–74)*	*Fifth Plan (1974–78)*	*Annual Plans (1978–80)*	*Sixth Plan (1980–85)*	*Seventh Plan (1985–90)*	*During (1990–92)*	*Target (1992–97)*	*Anticipated (1992–97)*	*End of 1996/97* *	*Anticipated addition (1997/98)*
Major/medium irrigation											
Potential	12.2	20.7	24.7	26.6	27.7	29.9	0.8	5.1	2.1	32.8	1.0
Utilization	11.0	18.7	21.2	22.7	23.6	25.5	0.8	4.3	2.1	28.4	0.9
Minor irrigation											
Potential	14.1	23.5	27.3	30.0	37.5	46.6	3.7	10.7	6.3	56.5	0.8
Utilization	14.1	23.5	27.3	30.0	35.3	43.1	3.4	9.4	5.8	52.3	1.4
Total irrigation											
Potential	26.3	44.2	52.0	56.6	65.2	76.5	4.5	15.8	8.3	89.3	1.8
Utilization	25.1	42.2	48.5	52.7	58.8	68.6	4.2	13.6	7.9	80.7	2.3

* anticipated achievement

Sources

1 Planning Commission. 1992 Eighth Five-Year Plan, 1992–97 Volume II p. 57 New Delhi: Planning Commission, Government of India 480 pp

2 MoF Economic Survey (various issues) New Delhi Ministry of Finance

For more details, please see TEDDY ONLINE+ [Section: agriculture (outlay and expenditure)]

Table 9

Irrigated area (million hectares) under selected crops: 1970/71 to 1995/96

Crops	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93 **	*1993/94 **	*1994/95 **	*1995/96 **
Rice	14.3	15.1	16.4	17.7	19.4	20.2	20.1	20.7	21.4	21.5
Total rice area (%)	38.4	38.2	40.8	42.9	45.5	47.3	48.0	48.6	49.8	50.1
Jowar	0.6	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Total jowar area (%)	3.6	5.0	4.7	4.5	5.6	6.5	6.1	6.2	6.7	7.0
Bajra	0.5	—	0.6	—	0.5	0.7	0.6	0.7	0.6	0.6
Total bajra area (%)	4.0	—	5.5	—	5.1	6.5	5.8	6.6	5.8	6.4
Maize	0.9	—	1.2	1.1	1.2	1.3	1.3	1.4	1.3	1.4
Total maize area (%)	15.9	—	20.1	18.7	19.7	22.5	21.5	22.6	21.3	22.7
Wheat	9.9	12.6	15.6	17.3	19.5	19.6	20.8	21.4	22.0	21.7
Total wheat area (%)	54.3	61.9	70.0	74.6	81.1	83.7	84.2	85.1	84.9	86.8
Barley	1.3	—	0.9	0.7	0.5	0.6	0.6	0.5	0.6	0.5
Total barley area (%)	52.0	—	50.6	51.4	54.5	60.7	60.8	58.1	66.7	61.3
Cereals	28.1	32.1	35.8	38.3	42.3	43.4	44.4	45.6	46.8	46.7
Total cereals area (%)	27.6	30.9	34.1	36.7	41.0	43.4	43.7	45.0	46.1	47.1
Pulses	2.0	2.0	2.0	2.1	2.6	2.4	2.5	2.6	3.1	3.1
Total pulses area (%)	8.8	8.0	9.0	8.5	10.5	10.7	10.5	11.2	12.8	13.0
Foodgrains	30.1	34.8	37.8	40.4	44.9	45.8	46.9	48.2	49.9	49.7
Total foodgrains area (%)	24.1	27.1	29.7	31.4	35.1	37.4	37.4	38.7	39.6	40.5
Oilseeds	1.1	1.2	2.3	3.4	5.8	6.8	6.4	6.5	6.8	7.3
Total oilseed area (%)	7.4	7.8	14.5	17.3	22.9	25.5	24.1	23.0	25.0	26.1
Cotton	1.4	1.7	2.1	2.3	2.5	2.6	2.7	2.6	2.7	3.1
Total cotton area (%)	17.3	22.8	27.3	30.2	32.9	33.3	34.6	34.3	33.8	34.8
Sugarcane	1.9	2.4	2.4	2.6	3.4	3.6	3.5	3.4	3.6	3.9
Total sugarcane area (%)	72.4	84.9	81.3	84.5	86.9	88.0	88.3	89.0	83.7	88.5

* provisional

Note

Irrigated area under oilseeds denotes the area under groundnut, rapeseed, mustard, linseed, sesamum, and others

Sources

1. MoA. Agricultural Statistics at a Glance (various issues). New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture.
2. MoF. 1999. Economic Survey, 1998/99 New Delhi: Ministry of Finance

For more details, please see TEDDY ONLINE+ [Section: Agriculture (irrigation-related statistics)]

Table 10

Irrigated area (million hectares) by various sources: 1970/71 to 1994/95

Source of irrigation	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*
Government canals	11.97	12.90	14.45	15.39	16.50	16.81	16.50	16.50	16.75
Private canals	0.87	0.90	0.84	0.49	0.51	0.49	0.48	0.48	0.48
Tanks	4.11	4.00	3.18	3.07	3.32	3.32	3.18	3.17	3.25
Tubewells	4.46	6.80	9.53	11.54	14.26	15.17	15.82	16.38	17.18
Other wells	7.43	7.60	8.16	8.62	10.09	10.87	11.11	11.39	11.72
Other sources	2.27	2.40	2.55	2.65	3.11	3.20	3.21	3.43	3.61
Total net irrigated area	**31.11**	**34.60**	**38.71**	**41.76**	**47.79**	**49.87**	**50.30**	**51.34**	**53.00**

Note

Due to rounding off, the total may not tally exactly.

Source

FAI 1998 Fertilizer Statistics, 1997/98 New Delhi. Fertilizer Association of India

For more details, please see TEDDY ONLINE+ [Section: Agriculture (irrigation-related statistics)]

Table 11

Consumption (million tonnes) of nitrogenous, phosphatic, and potassic fertilizers: 1970/71 to 1998/99

Fertilizer	*1970/71*	*1980/81*	*1985/86*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99* *
Nitrogenous	1.5	3.7	5.7	8.0	8.4	8.8	9.5	9.8	10.3	10.9	12.3
Phosphatic	0.5	1.2	2.0	3.3	2.8	2.7	2.9	2.9	3.0	3.9	4.4
Potassic	0.2	0.6	0.8	1.4	0.9	0.9	1.1	1.2	1.0	1.4	1.5
Total	**2.2**	**5.5**	**8.5**	**12.7**	**12.1**	**12.4**	**13.5**	**13.9**	**14.3**	**16.2**	**18.2**

* provisional

Sources

1 FAI 1997. Fertilizer Statistics, 1996/97. New Delhi Fertilizer Association of India.

2. MoF 1999 Economic Survey, 1998/99 New Delhi Ministry of Finance

For more details, please see TEDDY ONLINE+ [Section: Agriculture (fertilizer, pesticide, and other inputs)]

Table 12

Production and consumption (tonnes) of technical-grade pesticides: 1970/71 to 1995/96

Production/ consumption	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1989/90*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96* *
Production	23501	43262	54922	—	66470	75000	77000	—	—	—
Consumption	24320	45000	—	75000	72000	72130	70790	63650	61360	56110

anticipated achievement

Sources

1. Kothari Publications.1993. Indian Agriculture in Brief. Kothari's Deskbook Series The Pesticides Industry. p. 19. Chennai· Kothari Publications.
2. MoA. 1998. Agriculture Statistics at a Glance. p. 97. New Delhi: Ministry of Agriculture.

Table 13

Consumption of pesticides (tonnes): 1985/86 to 1994/95

State/union territory	*1985/86*	*1986/87*	*1986/87*	*1994/95*	*Share (%)*
State					
Andhra Pradesh	14400	9136	8860	13000	16.11
Arunachal Pradesh	17	18	25	42	0.05
Assam	810	1410	531	630	0.78
Bihar	1750	2000	3000	2600	3.22
Goa	56	55	11	12	0.01
Gujarat	4500	2090	2080	5100	6.32
Haryana	3608	3995	3700	5250	6.51
Himachal Pradesh	690	553	545	290	0.36
Jammu and Kashmir	748	92	85	142	0.18
Karnataka	3280	3265	4500	4400	5.45
Kerala	1130	1039	1059	700	0.87
Madhya Pradesh	3400	4000	3000	2757	3.42
Maharashtra	3089	6070	6090	6900	8.55
Manipur	43	40	38	42	0.05
Meghalaya	40	42	44	19	0.02
Mizoram	6	7	10	13	0.02
Nagaland	9	4	13	—	—
Orissa	1200	1400	1700	1700	2.11
Punjab	4620	5800	4860	6450	7.99
Rajasthan	2444	3240	2970	3900	4.83
Sikkim	16	18	20	32	0.04
Tamil Nadu	10000	11000	11600	9500	11.77
Tripura	190	160	138	100	0.12
Uttar Pradesh	6010	6550	6920	11000	13.63
West Bengal	5000	5100	4900	5823	7.22
Union territory					
Andaman and Nicobar Islands	7	4	4	19	0.02
Chandigarh	3	4	3	2	—
Dadra and Nagar Haveli	3	4	4	6	0.01
Daman and Diu	—	1	1	1	—
Delhi	40	46	50	75	0.09
Lakshadweep	4	1	1	2	—
Pondicherry	106	128	134	152	0.19

Source

CMIE. 1996. India's Agricultural Sector. Mumbai: Centre for Monitoring Indian Economy.

Table 14

Progress of farm mechanization: 1970 to 1993

Items	*1970*	*1974*	*1980*	*1985*	*1988*	*1993*
Gross cropped area (million hectares)	165.80	170.00	169.70	176.00	177.00	183.00
Tractors						
Cumulative totals (million)	0.10	0.23	0.47	0.82	1.05	1.80
Per million hectares of gross cropped area	610.00	1320.00	2790.00	4660.00	5950.00	9860.00
Oil engines						
Cumulative totals (million)	–	1.75	2.65	3.35	4250.00	5.20
Per Mha of gross cropped area	–	10320.00	15640.00	19690.00	24000.00	28490.00
Irrigation pump, electricity-operated tubewells						
Cumulative total (million)	1.35	2.43	3.97	5.71	7.00	9.62
Per million hectares of gross cropped area	8340.00	14280.00	23360.00	32360.00	39950.00	52710.00
Consumption of power (kWh) for irrigation per thousand hectares of gross cropped area	23.30	37.40	79.50	116.10	196.70	350.70

Sources

1 TERI 1995. Environmental Considerations and Options in Managing India's Long-term Energy Strategy (ECOMILES) p 59. New Delhi: Tata Energy Research Institute. 241 pp

2 MoPNG 1998 Basic Statistics on Indian Petroleum and Natural Gas p. 33. New Delhi. Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (mechanization)]

Table 15

Contribution of various energy sources to farm power: 1991/92

Source of farm power	*Number (million)*	*Total (GW)*	*Total (%)*
Human			
Male	149.20	8.95	7.32
Female	50.80	2.54	2.08
Draught animals	84.00	31.50	25.76
Tractors	1.30	29.10	23.80
Power tillers	0.09	0.54	0.44
Diesel engines	4.60	17.16	14.04
Electric motors	8.30	30.96	25.32
Combines	0.04	1.51	1.24

Source

TERI. 1995. Environmental Considerations and Options in Managing India's Long-term Energy Strategy (ECOMILES). p 59 New Delhi· Tata Energy Research Institute. 241 pp.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (mechanization)]

Table 16

Changes in various energy sources (number): 1971/72 to 1991/92

State	1971/72				1981/82				1991/92			
	Working bovine *	*Tractor* †	*Power tiller* †	*Pump (electric/diesel)*	*Working bovine*	*Tractor*	*Power tiller*	*Pump (electric/diesel)*	*Working bovine*	*Tractor*	*Power tiller*	*Pump (electric/diesel)*
Andhra Pradesh	66	1	0	2	55	27	2	9	63	48	1	16
Assam	141	0	0	0	138	0	0	0	157	0	23	1
Bihar	90	4	0	1	94	25	1	5	115	59	25	10
Gujarat	36	3	0	4	44	39	5	10	34	103	0	12
Haryana	31	32	0	3	38	216	41	11	22	387	317	17
Karnataka	44	0	0	2	44	18	10	5	42	50	11	7
Kerala	42	9	0	5	16	13	13	12	9	3	15	32
Madhya Pradesh	59	0	0	0	62	16	3	3	67	73	12	6
Maharashtra	40	15	0	2	41	12	0	7	38	34	2	10
Orissa	115	0	0	0	102	6	0	0	122	5	2	2
Punjab	47	107	0	8	34	399	478	23	20	1024	584	42
Rajasthan	26	4	0	1	25	20	7	4	17	91	10	9
Tamil Nadu	95	7	0	8	72	11	4	20	53	66	18	32
Uttar Pradesh	103	12	0	3	84	70	24	8	63	215	58	16
West Bengal	125	0	0	2	123	3	0	10	115	37	86	13
India	68	7	0	3	62	41	21	7	59	109	41	12

* Working bovine per 100 ha of operated area

† Tractors and power tillers per 10 000 ha of operated area

Source.

NSSO 1997 Land and livestock holding survey NSS 48th round 1992 New Delhi: National Sample Survey Organization, Department of Statistics, Government of India

Table 17

Energization of pumpsets: March 1995 to March 1998

	Energization of pumpsets			
State/union territory	*Cumulative (March 1995)*	*Cumulative (March 1996)*	*Cumulative (March 1997)*	*Cumulative (March 1998)*
Andhra Pradesh	1605807	1642993	1821291	1824689
Assam	0	3675	3675	3675
Bihar	264755	267371	269345	270277
Goa	5441	5732	6063	6454
Gujarat	551551	568858	591564	617495
Haryana	404107	406612	408461	409404
Himachal Pradesh	4141	4441	4780	5098
Jammu and Kashmir	3586	4716	5088	5621
Karnataka	973288	1014918	1049465	1082150
Kerala	289866	304904	314632	329355
Madhya Pradesh	1087404	1131435	1176317	1229016
Maharashtra	1883152	2025973	2091718	2151191
Manipur	45	45	45	45
Meghalaya	65	65	65	65
Mizoram	0	0	0	0
Nagaland	176	176	176	176
Orissa	65145	69184	70144	72047
Punjab	681432	709916	726221	735162
Rajasthan	488770	514758	539762	565068
Sikkim	0	0	0	0
Tamil Nadu	1487654	1528807	1567322	1609242
Tripura	1738	1764	1764	1764
Uttar Pradesh	727937	761272	778512	790157
West Bengal	98329	101232	102773	104383
Total (states)	**10585006**	**11068847**	**11529183**	**11812534**
Total (union territories)	**34578**	**35243**	**36159**	**36872**
Grand total	**10619584**	**11104090**	**11565342**	**11849406**

Source

Planning Commission. 1999 Annual Report on the Working of State Electricity Boards and Electricity Departments. New Delhi Power and Energy Division, Planning Commission, Government of India.

Table 18

Procurement/support prices (rupees per tonne) of foodgrains/commercial crops: 1970/71 to 1998/99

Crops	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Paddy	480	740	1050	1420	2050	2300	2700	3100	3400	3600	3800	4150	4400
Maize	550	740	1050	1300	1800	2100	2450	2650	2900	3100	3200	3600	3900
Wheat	760	1050	1300	1620	2250	2500	3300	3500	3600	3800	4150	4550	4700
Gram	—	—	—	2600	4500	5000	6000	6400	6700	7000	7400	8150	—
Sugarcane	73	85	130	165	220	260	310	345	391	425	459	485	527
Cotton	2990	2100	3040	4250	6200	6500	8000	9000	10000	11500	11800	13300	14400
Jute	1072	1350	1600	2150	3200	3750	4000	4500	4700	4900	5100	5700	6500
Groundnut	—	—	2060	3500	5800	6450	7500	8000	8600	9000	9200	9800	10400
Soyabean	—	—	1830	2500	3500	3950	4750	5250	5700	6000	6200	6700	7050
Mustard	—	—	—	4000	6000	6700	7600	8100	8300	8600	8900	9400	10000
Tobacco	—	—	—	11150	13250	14750	16000	18000	18500	19000	19000	20500	22500

Note

Prices are announced by the Government of India.

Sources

1. MoA. 1999. Agricultural Statistics at a Glance 1998. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.
2 MoF. Economic Survey (various issues) New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (prices)]

Table 19

Public sector plan outlays (million rupees) on agriculture sector during different five-year plans and annual plans

Agriculture. development	*Fourth Plan (1969–74)*	*Fifth Plan (1974–78)*	*Sixth Plan (1980–85)*	*Seventh Plan (1985–90)*	*Eighth Plan (1992–97)*	*Annual Plan*				
						1992/93	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Agriculture and allied activities	27280	46440	56950	105740	224670	47100	54090	58460	66610	69257
Agricultural research and education	—	—	5380	7050	20180	3360	4010	4520	5090	5213
Crop husbandry	5050	13220	12340	33120	92750	15600	18120	19710	20040	21553
Soil and water conservation	1590	2210	4340	7400	23050	3540	4330	4300	5130	4263
Animal husbandry and dairying	2330	4380	8510	10770	28380	4410	6270	6330	7160	6639
Fisheries	830	1500	3710	4990	12320	2170	2610	2730	3120	3077
Forestry and wildlife	930	2060	6930	18590	—	8130	9100	10270	10970	12176
Management of natural deserts	—	—	150	210	—	—	—	—	—	—
Agricultural marketing and rural godowns	940	—	960	1490	—	—	—	—	—	—
Food, storage, warehousing, and food processing	190	1240	3380	3070	5440	950	830	740	860	1104
Investment in agricultural financial institutes	3240	5190	8210	3540	5210	1700	1530	2550	5510	4487
Cooperatives	1790	3760	—	14010	30570	—	—	—	—	—
Plantation	—	—	—	1500	2070	740	880	880	1010	1031
Land reforms	—	1630	3050	—	10870	1570	1890	1970	2370	2857
Other agricultural programmes	—	1270	—	—	4690	810	740	770	630	1196
Irrigation and flood control	25830	42330	121600	169790	325250	49350	58540	64950	74730	97600
Major and medium irrigation	12370	30950	84480	115560	224150	31280	38410	42850	50460	70813
Minor irrigation	11740	7920	18100	28050	59770	10880	12160	14130	15200	17164
Command area development	—	—	8560	16710	25100	3580	4570	4760	5360	4309
Flood control including anti-sea erosion	1720	3460	10450	9470	16230	3600	3400	3210	3710	53014

Sources

1. Planning Commission Annual Plan (various issues) New Delhi. Government of India.
2. Planning Commission. Five-Year Plan (various issues) New Delhi: Government of India.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (outlay and expenditure)]

Table 20

Agricultural perspective

Variable	*1984/85*	*1991/92* *	*1996/97*	*2001/02*	*2006/07*
Land (million hectares)					
Net sown area	140.9	140.0	141.0	141.0	141.0
Gross growth area	176.4	182.2	190.6	197.2	203.4
Gross cropped area foodgrains	126.7	127.0	130.0	132.6	135.0
Irrigation (million hectares)					
Food grain	44.2	53.8	62.3	70.2	77.7
Non-food grains	16.3	21.9	27.0	31.8	36.3
Total	60.5	75.7	89.3	102.0	114.0
Fertilizer (million tonnes)					
Food grains	6.2	9.4	12.8	16.6	21.0
Non-food grains	2.1	4.1	5.5	7.1	9.0
Total	8.2	13.5	18.3	23.7	30.0
Cotton (million bales)	8.5	10.5	14.0	18.0	23.0
Sugarcane (million tonnes)	170.3	235.0	275.0	335.0	408.0
Food grains (million tonnes)	145.5	172.5	210.0	245.0	285.0
Oilseeds (million tonnes)	13.0	17.5	23.0	29.0	37.0

* likely assured base level

Source

MoA. 1999. Agricultural Statistics at a Glance 1998. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Table 21

India's livestock population: 1977 to 1992

Animals	Number of animals			
	1977	*1982*	*1987*	*1992*
Cattle	180140	192453	199695	204516
Buffaloes	62019	69783	75966	84239
Sheep	40907	48765	45703	50781
Goats	75620	95255	110207	115281
Horses and ponnies	916	900	797	817
Pigs	7647	10071	10625	12788
Mules	89	131	167	193
Donkeys	978	1024	958	966
Camels	1068	1078	1001	1031
Other livestock				
Yaks	132	128	36	58
Mithuns	129	154	—	—
Total	**369526**	**419588**	**445284**	**470824**

Source

MoA. 1999. Agricultural Statistics at a Glance 1998. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

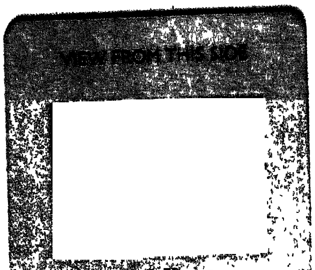
Table 22

All-India pattern of outlay and expenditure (million rupees) in public sector by plan

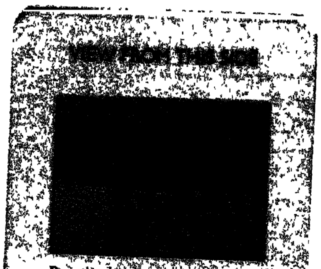
Plan period	*Agriculture and allied activities*		*Total*		*Percentage of agriculture and allied activities to total*	
	Plan outlay	*Actual expenditure*	*Plan outlay*	*Actual expenditure*	*Plan outlay*	*Actual expenditure*
First Plan (1951–56)	3540	2900	23780	19600	14.9	14.8
Second Plan (1956–61)	5100	5490	45000	46720	11.3	11.8
Third Plan (1961–66)	10860	10890	75000	85770	14.5	12.7
Annual Plan (1966–69)	10370	11070	66650	66250	15.6	16.7
Fourth Plan (1969–74)	27280	23200	159020	157790	17.2	14.7
Fifth Plan (1974–79)	47660	48650	393220	394260	12.1	12.3
Annual Plan (1979–80)	18150	19960	126010	121760	14.4	16.4
Sixth Plan (1980–85)	125390	152010	975000	1092920	12.9	13.9
Seventh Plan (1985–90)	222330	315090	1800000	2187300	12.4	13.4
Annual Plan (1990/91)	91420	85420	647170	583690	14.1	14.6
Annual Plan (1991/92)	100580	90600	723170	64750	13.9	139.9
Eighth Plan (1992–97)	636420	—	4341000	—	14 7	—
Annual Plan (1992/93)	104260	105370	807720	728520	12.9	14.5
Annual Plan (1993/94)	130020	126600	1001200	880810	13.0	14.4
Annual Plan (1994/95)	160210	154960	1121970	981670	14.3	15.8
Annual Plan (1995/96)	183630	173480	1285900	1199540	14.3	14.5

Source

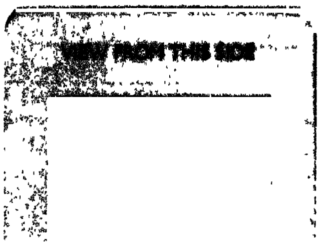
MoA. 1999. Agricultural Statistics at a Glance 1998. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.



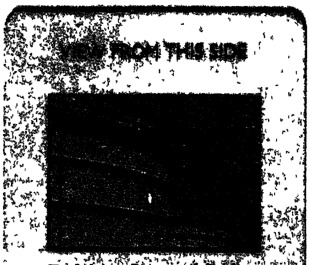
South Bassein Hazra onshore/offshore pipeline project for ONGC/Hyundai, Hazra.



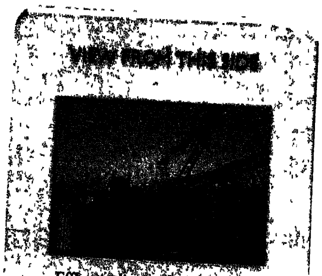
Raw water system for Chambal Fertilisers & Chemicals Ltd., Kota.



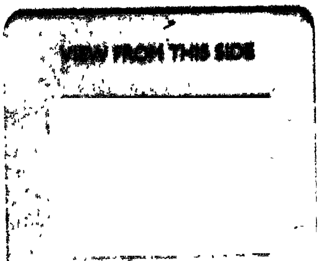
TNOR gas pipeline project, for TOTAL Indonesia/Bouygues Offshore, Kalimantan, Indonesia.



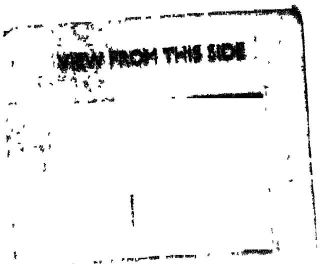
Tank farm, Ravva oil field development project, S. Yanam for Command Petroleum/Hyundai.



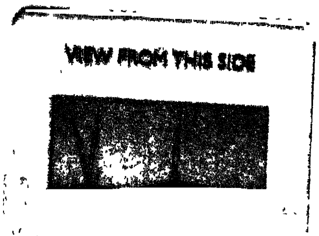
Effluent disposal pipeline project, Dahej for IPCL.



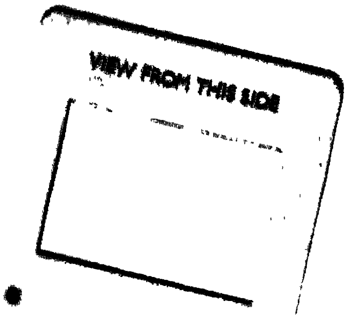
Piling work at Raja Garden flyover, New Delhi for UPSBC.



Gas gathering facility for Oil India Ltd., Jaisalmer.



Cryogenic tank, Marine tank farm for Reliance Refinery, Jamnagar.



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Industry

Introduction

The economic reforms initiated by the Government of India have led to a critical phase of transition and restructuring of the Indian industry. A number of policy initiatives were undertaken during the Eighth Plan. The thrust of the NIP (New Industrial Policy) was on (1) substantial reduction in the scope of industrial licensing; (2) simplification of procedures, rules, and regulations; (3) reforms in the MRTP (Monopolies and Restrictive Trade Practices) Act; (4) reduction of areas reserved exclusively for the public sector; (5) disinvestment of selected public sector enterprises; (6) enhancing limits of foreign equity participation in domestic industrial undertakings; (7) liberalization of trade and exchange rate policies; (8) rationalization and reduction of customs and excise duties; and (9) extension of the scope of MODVAT (modified value-added tax), etc.

The basic objectives of the NIP are to promote growth and to increase efficiency and international competitiveness. The general IIP (index of industrial production) recorded a growth rate of 6.6% in 1997/98 (at 1993/94 prices), aided by a growth rate of 5.9% in mining and quarrying, 6.6% in manufacturing, and 6.6% in electricity generation.[1] However, the modest growth rate of 6.6% is much lower than the 12.8% growth achieved in 1995/96 (Figure 1). In particular, the manufacturing sector, which had responded to economic reforms with dynamism (as revealed by the upward trend recorded in IIP since 1992/93), has witnessed a lower growth rate in 1996/97 for the first time.[2]

The Indian industry is currently going through a difficult phase (MoF 1999). Industrial growth, which decelerated to 6.6% in 1996/97, further declined in 1997/98 due to the poor performance of the manufacturing sector. At a more disaggregated micro level, the industrial slowdown in the manufacturing sector occurred mainly due to stagnation in the production of commercial vehicles, steel, sugar, a number of items from the capital goods industry, scooters, a certain variety of automotive tyres, etc.

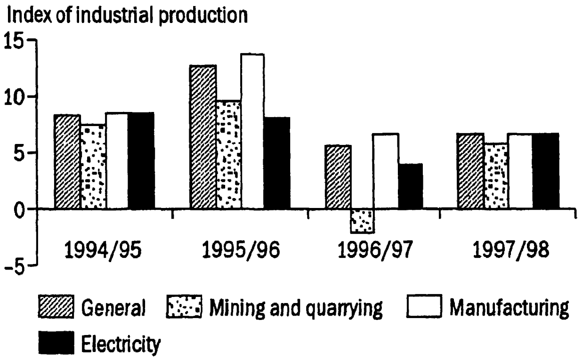

Figure 1 Performance of industrial sector
Source MoF (1999)

The industrial sector consumes about 50% of the total commercial energy produced in the country. The total industrial energy consumption, including non-energy uses, grew from 45.7 MTOE (million tonnes of oil equivalent) in 1984/85 to 113.1 MTOE in 1996/97. Of the commercial sources of energy, coal and lignite contribute about 57%, oil and natural gas around 33%, hydroelectric power 3%, and nuclear power 0.2%. Consumption of different kinds of fuels in industry is provided in Table 1 for the period 1990/91 to 1996/97.

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[1] Manufacturing sector has an overwhelming weight of 79.36% IIP, followed by mining (10.47%) and electricity (10.17%).

[2] Manufacturing sector comprises 17 industry groups of National Industrial Classification at two-digit level. Broadly, it includes food products, cotton and jute textiles, wood paper, and leather products.

This chapter focuses on seven energy-intensive industries, namely, fertilizers, aluminium, iron and steel, textiles, cement, chemicals, and pulp and paper. Though these industries account for nearly 80% of the total industrial energy consumption, there is tremendous scope for improving energy efficiency as well.

Fertilizer

There exist mainly three types of fertilizers – nitrogenous, phosphatic, and potassic. The share of phosphatic fertilizers is insignificant and India does not produce potassic fertilizers. India operates nearly 40 nitrogen fertilizer plants and ranks fourth in the world in terms of production.

The capacity utilization of the nitrogenous fertilizer plants increased from 52.8% in 1980/81 to 95.9% in 1997/98 (Table 2). This was on account of higher capacity utilization of gas-based plants from the newly-found reserves of natural gas in Bombay High and South Basin, resulting in an increase in offtake of natural gas from 611 million cubic metres in 1980/81 to 6936 million cubic metres in 1994/95. This increased further to 7602 million cubic metres in 1995/96 (excludes offtake of natural gas by the Oil and Natural Gas Corporation Ltd [ONGC]). The shares of capacity of nitrogenous fertilizer plants in 1997/98 among the public, cooperative, and private sectors were 41.1%, 21.5%, and 37.4%, respectively. During 1990/91 to 1997/98, the import of nitrogenous and phosphatic fertilizers increased, but now it is showing a decreasing trend (Table 3).

The fertilizer industry, particularly nitrogenous fertilizers, is highly energy-intensive. The fertilizer industry is also one of the largest consumers of petroleum-based fuels. The consumption of these fuels has increased from 4103 thousand tonnes in 1990/91 to 5024 thousand tonnes in 1994/95 (Table 4).

The energy consumed in the production of ammonia has a great impact on the overall energy consumption scenario of the entire fertilizer industry. Production of ammonia accounts for more than 80% of the total energy consumed by a finished fertilizer product. The specific energy consumption for ammonia production is given in Table 5. The Indian ammonia industry during the last four decades witnessed many changes in feedstock, technology, etc., which resulted in substantial improvement in the overall energy-use efficiency.

The shares of different feedstocks in nitrogenous fertilizer production during 1997/98 were as follows: natural gas 54%, naphtha 30.8%, fuel oil 12.1%, and coal 3.1%. In terms of calorific content, natural gas is the largest source of energy in the fertilizer industry. Therefore, new/expansion projects are moving towards naphtha/natural gas-based fertilizer plants. This change is attributed to the high specific energy consumption and pollution problems associated with fuel oil and coal-based fertilizer plants.

Recent advances in process technology and catalysts have also resulted in lower energy intensity. The energy conservation options for ammonia plants (process by stage) include reformer tubes of superior material, adiabatic pre-reformer, and reduction of steam/carbon ratio. Conservation options for ammonia synthesis include purge gas recovery unit, make-up gas chiller at suction, synthesis converter revamp, and computer control and optimization.

In the case of urea plants, the energy conservation options include urea hydrolizer stripper, incorporation of trays inside the reactor, use of coil to feed the reactants from the top to the reactor, use of internal heat recovery system, and vacuum preconcentrator.

The energy efficiency of India's fertilizer industry could be improved by the construction of new natural gas-based plants and replacing old coal-based plants. Revamping measures could improve the efficiency of the naphtha-based plants (constructed during the 1970s) and the natural gas-based plants (constructed in the early 1980s).

In addition to technical measures as highlighted above, there are policy issues that have a profound impact on energy/environment performance of this sector. The NIP unveiled in July 1991 announced the delicensing of the fertilizer industry. Promoters are now free to set up fertilizer plants in the country without obtaining any license from the government provided they obtain environmental clearance.

Some of the recommendations of the high-powered fertilizer pricing policy review committee are listed below.

- Deregulate the fertilizer industry; allow units to fix their retail pricing subject to ceiling farm prices.
- Encourage restructuring of plants based on naphtha, fuel oil, and coal to move over to more energy-efficient feedstock.

- Promote the use of balanced fertilizer and relative prices of fertilizers should reflect the desirable.
- In light of the current relative pricing of different feedstocks, future fertilizer production should be appropriately based on domestic natural gas and LNG (liquefied natural gas).

Aluminium

The aluminium industry in India, which began in the 1930s, has taken a leap forward during the past five decades. The installed capacity has increased from 4000 tonnes in 1950 to 625 000 tonnes in 1994/95. The installed capacity, production, and capacity utilization of the aluminium industry are given in Table 8. At present, five companies (two in the public sector and three in the private sector) are producing aluminium. They are (1) the Bharat Aluminium Company Limited at Korba, Madhya Pradesh; (2) the Indian Aluminium Company Limited at Belgaum in Karnataka, Hirakud in Orissa, and Alwaye in Kerala; (3) the Hindustan Aluminium Company Limited at Renukoot, Uttar Pradesh; (4) the Madras Aluminium Company Limited at Mettur, Tamil Nadu; and (5) the National Aluminium Company Limited at Damanjodi, Orissa. The plantwise installed capacity, production, and capacity utilization are given in Table 7.

Bauxite is the basic raw material used for the production of aluminium. India possesses nearly 8.3% of the total known reserves of bauxite in the world (2650 MT [million tonnes] out of world's reserves of 32 000 MT). The BHH (Bayer-Hall-Heroult) process has practically remained the only viable commercial manufacturing process ever since the discovery of aluminium in 1886.

Aluminium production is a highly energy-intensive process with energy accounting for nearly 40% of the production cost. Considerable R&D efforts are being made to improve the worldwide-accepted BHH technology and also to find an alternative process. Several organizations are experimenting with new production processes which they claim have significant advantages over the BHH process. However, these processes are either at the laboratory stage or under pilot operation.

The consumption of aluminium grew by nearly five per cent annually during the Eighth Plan. This was mainly due to the slowdown of the economy, resource constraints faced by the state electricity boards, and lower investment in aluminium consuming sectors because of liquidity crunch in the economy. The Ninth Plan targets eight per cent growth in demand for aluminium and an increase in installed capacity from 670 000 tonnes a year to 714 000 tonnes a year.

The two major energy-consuming steps in the production process are the conversion of bauxite ore to alumina and the production of aluminium from alumina. About 2.5 tonnes of bauxite is required to produce one tonne of alumina and about two tonnes of alumina is required to produce one tonne of aluminium. Tables 9 and 10 show the specific energy consumption and performance parameters, respectively, of Indian aluminium plants. Fuel oil is used for firing calcining kilns. Besides calcination, some units also use fuel oil to generate steam required for digestion and evaporation. Coal is used only for steam generation whereas electricity is largely used in the smelting and grinding of bauxite.

Electricity, coal, and fuel oil are the major forms of energy used by the aluminium sector with electricity accounting for 80% of the total energy use. Based on 1994/95 figures, the total energy consumed by all primary producers in the country is estimated to be 30.1 Gcal.

Electrical power is utilized in smelters for aluminium production. Some of the energy-saving options identified in smelters are given below.

- Provision for mechanized and automatic alumina feeding facilities
- Automation and mechanization of cell operation by introducing microprocessors and computers
- Improvement in cathode lining and cell design
- Improvement in anode design, possibility of increasing anode areas by redesigning the existing cell
- Provision for efficient gas cleaning and recovery of fluorides by dry scrubbing system.

It is analysed that with a coordinated approach on all fronts, energy saving in the range of 15%–20% of the total energy use can be achieved.

New energy-efficient technologies

Though Indian companies have taken measures in recent years to reduce specific power consumption, it is still significantly higher than the international norms. Considerable R&D efforts are being made to improve the BHH technology and also to find an alternative process route, which is less energy-intensive and less costly for aluminium production (TERI 1996). Some of the promising processes include Carbothermic, Toth, and Kuwahara.

Textile

The textile industry is the single largest organized industry in India accounting for about four per cent of the GDP (gross domestic product) and one-fifth of the total industrial output (TERI 1996). It accounts for around one-third of the total export earnings and provides employment to over 20 million people. The textile industry comprises cotton, wool, silk, synthetic fibre, and jute. Cotton textile manufacture, the predominant sub-sector in the textile industry, consists of both the organized and decentralized sectors, which use both powerlooms and handlooms.

The production of man-made fibre and yarn has increased significantly from 223 million kg in 1980/81 to 1477 million kg in 1997/98. The production of fabrics registered an increase from 27 898 million square metre in 1993/94 to 37 436 million square metre in 1997/98 (MoF 1999). While the share of mill sector in fabric production has declined from 7.1% in 1993/94 to 5.2% in 1997/98, the share of powerlooms has increased from 70.4% to 73% during the same period (Table 11).

The number of cotton and man-made fibre textile mills (comprising cotton yarn, blended yarn, and other man-made fibre yarn manufacturing units and the composite units) rose from about 700 in the beginning of 1980s to 1782 by the end of March 1998. During the same period, the spindleage capacity increased from 21 million spindles to about 34 million spindles. The growth process in the spinning sector has been marked by the installation of more number of rotors, which now stands at 313 000. The weaving capacity declined between 1980 and 1998 by about 85 000 looms. However, in 1990, this was compensated by the emergence of the decentralized powerloom sector in a big way. In recent years, a number of EOUs (export-oriented units) mainly for the production of cotton yarn have come up. The number of EOUs has increased from 30 in 1994 to 82 in 1998. Textile exports have grown from 6600 million dollars in 1992/93 to 11 389 million dollars in 1996/97.

About 81% of the textile mills are still in the private sector while 8.5% of the units are in the cooperative sector, and 10.5% in the public sector (central and state). The private sector mills account for about 69% of the spindle capacity and 56% of the loom capacity, while the remaining 27% of the spindle capacity and 45% of the loom capacity are shared by both the public sector and cooperative sector units.

The textile industry accounts for nine per cent of the total commercial energy use in India (TERI 1996). Coal and furnace oil are used for process heat requirements. All textile mills, except those around Mumbai, use coal in their boilers. An estimated 80%–90% of the electricity used is motive power for driving pumps, motors, drives, etc. The expenditure on energy of most textile mills accounts for 10%–15% of the total input costs (TERI 1996). However, the consumption can be substantially reduced.

The energy consumption in the various sub-sectors of textile industry is given in Table 12. Coal is the major fuel consumed in this sector although its share both in absolute and relative terms as against oil and gas and electricity has declined. The share of coal has registered a decline from nearly 50% in 1985 to 41% in 1994/95 out of the total energy consumed. Coal appears to have been replaced by oil and gas registering a 10% increase in their share between 1985 and 1994/95, while the share of electricity has been more or less constant at 30% (TERI 1998). However, efficient use of electricity is observed only in the case of cotton and blended yarn as against cotton and polyester filament yarn. Productwise energy intensity, sectionwise power consumption, and specific electricity consumption of the textile industry are given in Table 13, Table 14, and Table 15, respectively.

Fuel and power account for 12%–15% of the total cost of production at present, registering an increase of 3%–4% of the total production cost in 1984/85 (TERI 1996). The overall energy-saving potential in this sector is estimated to be 23%. The major energy-saving opportunities are listed below.

- Installation of radio frequency drier
- Use of smaller wrap diameter spindle
- Use of single-stage bleaching process
- Use of resin finishing
- Use of low energy bleaching process
- Rapidogen development
- Use of low temperature curing of pigment prints
- Use of foam technique of printing and finishing

In addition to the measures mentioned above, there is a possibility of utilizing renewable sources of energy, specifically solar thermal applications for generating low-grade heat. Surveys show that 25%–30% of the mills have not adopted any energy conservation measures. It is estimated that in the steam-using mills, about 10% of the electricity requirements can be met by installing cogeneration equipment.

Cement

India is the third largest cement producing country in the world. In spite of the rapid growth in this industry, the per capita consumption of cement in India is still one of the lowest in the world. The per capita consumption in India is 57 kg, while that of the Organization for Economic Cooperation and Development countries is 465 kg. Official estimates show that as on 31 March 1997, there were 115 large cement plants and about 300 mini plants in the country. The installed capacity has increased from 3.25 MT in 1950/51 to 96 MT as on 31 March 1997 due to significant technological advances in the cement manufacturing industry (Table I). The demand for cement is expected to reach 109 MT during the terminal year of the Ninth Plan (2001/02). The capacity and production targets for the same year are placed at 135 MT and 113 MT, respectively. The overall growth of the cement industry for the period 1985/86 to 1997/98 is given in Table 16.

The Indian scenario presents a view of the complementary role being played by old technological processes and the present-day mini cement plants as against the energy-efficient dry process plants. The Indian cement industry comprises 115 large rotary kiln cement plants and another 300 kilns in the mini cement plants category (mainly vertical shaft kilns of various sizes). In the past four to five years, all cement units based on the wet kiln process have been converted into energy-efficient and environment-friendly dry process plants. These plants account for over 80% of the total cement production in the country. The growth, however, is not due to the modernization of the old wet process plants alone, but substantially due to the increased installed capacity of dry process plants. The consumption of various forms of energy in the cement industry is given in Table 17 for the period 1989/90 to 1996/97.

Table I Status of large and mini cement plants as on March 1997

Size of cement plants	*Number of plants*	*Installed capacity (million tonnes)*	*Cement production (million tonnes)*
Large	115	96	70.00
Mini	300	90	6.24

Source CMA (1997)

The industry is quite energy-intensive and the main source of energy is coal with a predominant share of nearly 88% in 1994/95. There appears to be no discernible shift in the fuel-use pattern. The contribution of other fuel types, namely, oil and gas and electricity, is quite modest at five per cent and eight per cent, respectively, in 1994/95. Energy consumption norms for the cement industry are shown in Table 18. Also, specific energy consumption in dry as well as wet technology plants in India compared to other countries is given in Table 19. It can be conservatively stated that at least 10% savings in both thermal and electrical energy consumption is possible by adopting various energy conservation measures.

The cement industry has been delicensed subject to certain locational restraints. Private parties can set up cement plants in various areas as long as they meet the required environmental standards. The Ministry of Industry is trying to meet the high standards of coal requirements by suggesting the setting up of several washeries around the country to meet the high standards of low ash cement coal.

A few selected energy conservation measures in the cement industry are listed below.

- Install raw material composition control equipment for improving raw meal quality
- Introduce a vibrating screen with reversible impactor for raw grinding and precrushing of clinker
- Install a microprocessor-based coal-feed system for accurate control of coal feed
- Stop idle running of auxiliaries
- Install air seal for kiln outlet
- Install high efficiency and high velocity burners to improve heat recovery
- Install secondary firing system

Iron and steel

The iron and steel industry is the largest consumer of energy in the industrial sector. Energy costs constitute 30% of the total production costs of iron and steel. Two processes for production are common in India, namely, ISPs (integrated steel plants) (technically defined as BF-OH [blast furnace-open hearth], and BOFs [basic oxygen furnaces]) and mini-steel plants (scrap or sponge iron-based EAFs [electric arc furnaces]). India has 269 EAFs, with a total steel making capacity of 9.3 MT a year. During 1997/98, the actual production of finished steel was 23.37 MT. The production of sponge iron stood at 5.3 MT in 1997/98. The production data for finished steel, sponge iron, and ingot steel are given in Tables 20, 21, and 22, respectively. Also, crude steel production in India and a few other major producing countries is given in Table 23. The consumption of finished steel increased by 2.2% in 1997/98 and stood at 22.6 MT.

The primary sources of energy utilized by ISPs are coking coal, non-coking coal, liquid hydrocarbons, and electricity, of which coking coal accounts for 65%–80% (FRIC 1996). The two most energy-intensive steps in these plants are making iron in blast furnaces and liquid steel from the hot metal in blast furnaces. The process of making iron consumes nearly 70% of the total energy consumption at the plant.

Electricity is a major source of energy for making steel. Most of the integrated steel plants have their own captive power plant for electricity generation. Details regarding electricity generated, purchased, and consumed in the main steel plants in the country during 1990/91 to 1994/95 are given in Table 24. The EAFs are too small for captive power plants to be economically viable. The small size of furnaces and the erratic power supply have led to high electricity consumption in Indian EAFs ranging from 500 to 880 kWh/tonne of crude steel. The electricity consumption has registered an increase from 530 to 604 kWh/tonne of production. Recently, the private sector was invited to set up these plants with annual production capacities ranging from a minimum of 25 000–30 000 tonnes up to 1 MT.

Although substantial energy conservation measures have been adopted in ISPs in India, their performance leaves a lot to be desired when compared to their counterparts in other countries. Efforts are in progress to reduce energy consumption further by importing good-quality coking coal, phasing out open-hearth furnaces for steel making, and introducing more continuous casting. The Ninth Plan would focus on: (1) producing 58 MT of finished steel by 2002–07, (2) adopting ISO 9000 series certification and TQM (total quality management) by steel plants, (3) promoting more private investment, and (4) achieving the export target of 6 MT of finished steel by 2001/02.

Pulp and paper

The pulp and paper industry is the sixth largest energy consumer in the country. As of now, India has 406 pulp and paper mills with an installed capacity of 6.12 MT a year. Table 27 gives the installed capacity, production, and capacity utilization of paper industry in India for the period 1950/51 to 1994/95. The Indian paper industries use a broad mix of raw materials like wood/bamboo (37%), agro-residues (31%), and waste paper (32%) (Rao, Bhattacharya, and Banerjee 1998). The product range of the industry can be broadly classified into paper and paper board segment and newsprint segment. The paper and paper board segment can be further classified into writing and printing paper, wrapping and packaging paper, paper board, and special paper.

The low capacity utilization in the pulp and paper industry is because of the acute shortage of raw materials, erratic power supply, shortage of fuel, market forces, etc. India's per capita paper consumption is only 3.6 kg a year, as compared to the world average of 45.6 kg a year. It is expected to rise to 5 kg a year by 2000/01 (Rao, Bhattacharya, and Banerjee 1998).

Energy accounts for 30% of the total manufacturing cost and is rising every year. Specific energy consumption in different process centres in the paper industry is given in Table 28. In India, the average annual production capacity of a plant is 10 000 MT only, which is very low compared to the Asia–Pacific region (85 000 MT) and South-East Asia (50 000 MT). The reason for this lower production capacity is the high cost of setting up a new plant. As compared to the larger mills, which are more efficient and have low costs of production, the smaller mills do not have chemical recovery systems and cogeneration, thus making them less efficient and increasing the production costs.

Chlor-alkali

The chlor-alkali industry comprises mainly caustic soda, soda ash, and chlorine manufacturing plants. Caustic soda and its co-product chlorine are used in large quantities in the production of organic chemicals and plastics, in the pulp and paper industry, aluminium industry, water and waste water treatment facilities, and in a number of other industries.

At present, there are 38 caustic soda and 7 soda ash plants operating in India. These units now have a surplus manufacturing capacity. The installed capacity, production, and capacity utilization in the chlor-alkali industry are given in Table 30.

Caustic soda is mainly produced by the electrolysis of sodium chloride (common salt). In the electrolysis process, three types of cells are in use – diaphragm cell, mercury cell, and membrane cell. In India, the caustic soda industry began with the diaphragm electrolytic cells. The overall energy cost is high and the quality of the product is inferior. However, there is no serious pollution problem using diaphragm cells. Mercury cells are widely used as they consume less power and produce almost 50% concentrated caustic liquor, which is sold as it is. Heavy metal pollution due to the presence of mercury in effluents is a hazard. Removing mercury from the effluents has, however, effectively solved this problem. The share of membrane cell in the total production grew from 1.7% in 1987/88 to 52.13% in 1997/98. This is attributed to the commissioning of new plants with membrane cell process in the recent years. The membrane cell process is more energy efficient than other major processes of production.

The main steps in the manufacturing process of soda ash comprise pulverizing the salt, brine-purification, absorption of ammonia in brine (ammoniated brine), and carbonation to form sodium bicarbonate and ammonium chloride. The sodium carbonate precipitate is filtered in rotary vacuum filters and calcined in rotary calciners to obtain soda ash.

Some chlor-alkali units have installed turbogenerators to meet a large part of their power requirements since a substantial quantity of steam is required at low pressure for the process.

In the chlor-alkali industry, energy accounts for 50%–65% or more of the total cost of production. Therefore, energy conservation has become a matter of concern, forming an integral part of plant operations. Specific energy consumption in different sections in the soda ash industry is shown in Table 31. Table 32 gives the consumption of various forms of energy for manufacturing caustic soda. The energy-saving potential in the chlor-alkali industry is estimated at 15% of the total energy use by the sector. In the caustic soda industry, the major energy-saving measure that can be implemented is to convert the existing mercury or diaphragm cell process to membrane cell technology. In the soda-ash sector, the major energy-saving measures are (1) the use of improved heat exchangers for ammonia recovery system and (2) the use of dry lime in ammonia still for heat recovery.

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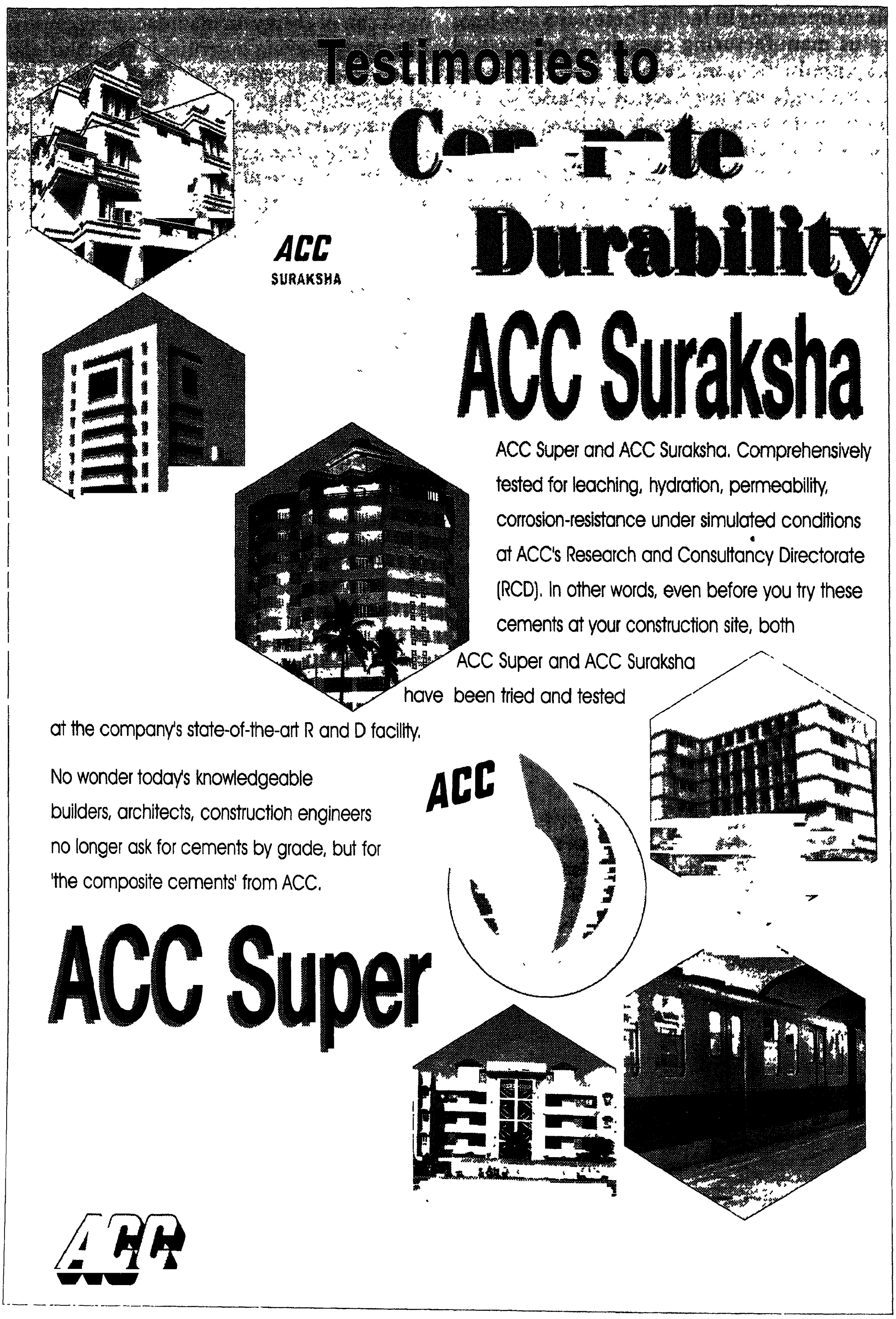

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Table 1

Energy consumption in industry: 1990/91 to 1996/97

Fuel consumption	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Electricity purchased from utilities (GWh)	25640.0	26547.0	28221.6	31908.0	32061.0	33941.0	—
Self-generated electricity (GWh)	21142.3	23556.1	25977.8	26862.0	29709.0	32438.0	—
Electricity (GWh)	46782.3	50103.2	54199.4	58770.0	61769.0	66379.0	—
Fuel oil (thousand tonnes)	3150.0	3692.0	3962.0	3603.0	3944.0	4836.0	4691.0
Naphtha (thousand tonnes)	3446.0	3461.0	3382.0	3191.0	3400.0	3669.0	4015.0
* High - speed diesel (thousand tonnes)	1431.0	1416.0	1489.0	1512.0	1783.0	2386.0	2816.0
* Light diesel oil (thousand tonnes)	638.0	644.0	647.0	625.0	641.0	700.0	633.0
† Liquefied petroleum gas (thousand tonnes)	487.0	486.0	544.0	635.0	654.0	737.0	774.0
‡ Coal (million tonnes)	89.1	91.8	93.9	94.5	103.6	95.48	95.51

* excludes plantation and food

† includes commercial sector

‡ consumption and supply of raw coal includes steel and washery, cement, cotton, jute, paper, brick, and other industries

Sources

1. CEA Public Electricity Supply, All India Statistics, General Review (various issues) New Delhi. Central Electricity Authority
2. MoC Coal Directory of India (various issues). Calcutta. Coal Controller's Organization, Ministry of Coal.
3. MoPNG Indian Petroleum and Natural Gas Statistics (various issues). New Delhi Economic and Statistics Division, Ministry of Petroleum and Natural Gas.
4. FAI 1998 Fertilizer Statistics 1997/98 p II–65. New Delhi: The Fertilizer Association of India

Table 2

Installed capacity, production (thousand tonnes of nutrients), and capacity utilization (%) in the fertilizer industry: 1990/91 to 1997/98

Parameter	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Nitrogenous								
Installed capacity	8147.0	8282.0	8510.0	8844.0	8998.0	9134.2	9468.2	10518.4
Production	6993.1	7301.5	7431.0	7231.2	7944.3	8768.8	8593.1	10083.0
Capacity utilization	85.7	88.7	88.1	84.1	91.0	98.5	93.2	95.9
Phosphatic								
Installed capacity	2765.0	2806.0	2806.0	2817.0	2873.0	2982.0	3027.3	3135.3
Production	2051.0	2562.0	2321.0	1874.3	2562.6	2593.5	2578.6	3058.3
Capacity utilization	74.2	94.0	83.3	68.5	90.9	90.7	86.1	97.5

Source

FAI Fertilizer Statistics (various issues). New Delhi The Fertilizer Association of India

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 3

Imports (thousand tonnes of nutrients) of fertilizers: 1990/91 to 1997/98

Type	*1990/91*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Nitrogenous	414	1137	1564	1476	1938	1155	1362
Phosphatic	1311	967	687	722	380	246	672
Potash	1328	1082	880	1109	1423	613	1140
All India	**3053**	**3186**	**3131**	**3307**	**3741**	**2014**	**3174**

Source

MoF. 1999. Economic Survey 1998/99. p. S–27. New Delhi: Ministry of Finance.

Table 4

Energy consumption in the fertilizer industry: 1990/91 to 1994/95

Energy form	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*
Naphtha (thousand tonnes)	1842.0	1770.0	1678.0	2172.0	2495.0
Furnace oil (thousand tonnes)	1058.0	1404.0	1348.0	1160.0	1507.0
Low sulphur heavy stock/hot heavy stock (thousand tonnes)	1184.0	1046.0	1002.0	1052.0	1001.0
High speed diesel/light diesel oil (thousand tonnes)	19.0	27.0	21.0	12.0	21.0
Coal (million tonnes)	4.0	4.3	4.6	5.0	4.3
† Electricity (GWh)	4906.2	5012.7	5469.4	5700.0	—

† includes energy used out of self-generation

Sources

1. CEA. Public Electricity Supply, All India Statistics, General Review (various issues). New Delhi: Central Electricity Authority.
2. MoC. Coal Directory of India (various issues). Calcutta: Coal Controller's Organization, Ministry of Coal.
3. MoPNG Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 5

Specific energy consumption (Gcal/tonne) of ammonia: 1988/89 to 1992/93

Feedstock	*1988/89*	*1989/90*	*1990/91*	*1991/92*	*1992/93*
Gas	10.0	9.6	9.6	9.6	9.5
Naphtha	12.2	12.4	11.9	11.7	11.7
Fuel oil	14.3	14.4	15.1	13.5	13.9
Coal	33.8	38.9	39.1	39.7	42.7

Source

TERI. 1995. Environmental Considerations and Options in Managing India's Long-term Energy Strategy (ECOMILES). p 40. New Delhi· Tata Energy Research Institute. 241 pp.

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 6

Specific energy consumption (Gcal/tonne) of phosphatic fertilizer plants: 1991/92 to 1993/9

Plant and products	*1991/92*	*1992/93*	*1993/94*
Gujarat State Fertilizer Corporation, Baroda			
Sulphuric acid	–0.47	–0.46	–0.58
Phosphoric acid	1.72	1.58	1.64
Di-ammonium phosphate	0.22	0.20	0.13
Gujarat Narmada Fertilizer Corporation, Bharuch			
Nitrophosphate	1.42	1.41	1.23

Note

Negative value implies that the total energy input is less than the energy equivalent of the steam generated in waste-heat boilers

Source

Compiled by TERI, New Delhi.

Table 7

Capacity, production, and capacity utilization of aluminium companies: 1994/95

Company	*Location*	*Capacity (thousand tonnes)*	*Production (thousand tonnes)*	*Capacity utilization (%)*
Indian Aluminium Company Ltd	Belgaum (Karnataka), Alupuram (Tamil Nadu), Hirakud	117	43	37
Bharat Aluminium Company Ltd	Korba (Madhya Pradesh)	100	93	93
National Aluminium Company Ltd	Damonjodi (Orissa)	218	178	82
Hindalco Industries Ltd	Renukoot (Uttar Pradesh)	165	164	99
Madras Aluminium Company Ltd	Mettur (Tamil Nadu)	25	–	–
Total	–	**625**	**478**	**77**

production restarted in late 1994/95

Source

BICP November 1995 Energy Efficiency of Indian Aluminum Industry p. 7. New Delhi Bureau of Industrial Costs and Prices, Ministry of Industry. 89 pp

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 8

Installed capacity (thousand tonnes), production (thousand tonnes) and capacity utilization (%) of the aluminium industry: 1980/81 to 19

Item	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Installed capacity	331.0	362.0	580.0	625.0	625.0	625.0	625.0	–	–	–
Production	199.0	260.0	451.0	512.0	486.0	460.7	479.8	518.0	524.0	554.4
Capacity utilization	60.1	71.8	77.8	81.9	77.8	74.4	76.5	–	–	–

Sources

1. Compiled by TERI, New Delhi.
2. MoF 1999 Economic Survey 1998/99 p. S–34 New Delhi: Ministry of Finance

Table 9

Specific energy consumption per tonne of aluminium: 1992/93 to 1994/95

	Specific energy consumption in smelting per tonne of aluminium			
	Electrical		*Thermal*	*Total*
Plant and year	*kWh*	*(GJ/tonne)*	*(GJ/tonne)*	*(GJ/tonne)*
National Aluminium Company Ltd				
1992/93	15180	54.62	3.72	58.34
1993/94	15086	54.28	3.75	58.03
1994/95	15548	55.95	4.15	60.09
Hindalco Industries Ltd				
1992/93	15155	54.53	2.75	57.28
1993/94	15098	54.33	2.80	57.13
1994/95	15341	55.21	2.53	57.74
Bharat Aluminium Company Ltd				
1992/93	17772	63.95	0.71	64.66
1993/94	18173	65.39	0.85	66.24
1994/95	18022	64.85	1.11	65.96
Indian Aluminium Company Ltd				
1994/95, Alupuram	17385	62.56	0.77	63.33
1994/95, Hirakud	16625	59.82	0.64	60.46
1994/95, Belgaum	17921	64.49	0.85	65.34

Source
Compiled by TERI, New Delhi.

Table 10

Performance parameters (per tonne of calcined alumina) of Indian aluminium plants: 1994/95

				Indian Aluminium Company Ltd	
Parameter	*Hindalco Industries Ltd*	*Bharat Aluminium Company Ltd*	*National Aluminium Company Ltd*	*Belgaum* †	*Muri*
Bauxite (tonnes)	2.73	2.63	2.77	2 80	3.07
Caustic (kg)	100.00	80 00	60 00	110.00	140.00
Lime (kg)	148.00	229.10	57.30	—	—
Coal (tonnes)	0.95	0.59	0.70	—	1.35
Steam (tonnes)	4 10	3.34	—	—	—
Fuel oil (litres)	80.00	130.00 *	90.00	231 00 *	110.00
Power (kWh)	428.00	470.00	413 00	268.00	—
Total energy consumption (GJ)	**16.36**	**16.51**	**13.21**	—	—

* includes consumption for steam generation

† does not use coal for steam generation leading to very high consumption of fuel oil

Source
Compiled by TERI, New Delhi.

Table 11

Production by the textile industry: 1990/91 to 1997/98

Products	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98* *
Jute textiles (thousand tonnes)	1430	1378	1310	1451	1364	1430	1401	1678
Cloth (million m^2)								
Cotton cloth								
Mill sector	1859	1651	1453	1990	2271	2019	1957	1948
Decentralized sector	13572	12996	11601	15800	14748	16881	17884	18044
Sub-total	**15431**	**14647**	**13054**	**15576**	**17019**	**18900**	**20131**	**19992**
Mixed and blended cloth								
Mill sector	689	666	533	575	566	487	607	—
Decentralized sector	1682	2046	2003	2428	2725	2896	3123	—
Sub-total	**2371**	**2712**	**2536**	**3003**	**3291**	**3383**	**3730**	—
Man-made fibre fabrics								
Mill sector	41	59	—	—	—	—	—	—
Decentralized sector	5085	5086	5170	—	—	—	—	—
Sub-total	**5126**	**5145**	—	—	—	—	—	—
Spun yarn (by cotton textile mills) (million kg)								
Cotton	1510	1450	1523	1697	1696	1894	2148	2029
Mixed and blended	207	234	247	305	346	395	484	533
100 per cent non-cotton	107	122	125	140	158	196	162	164
Filament yarn								
Cellulosic								
Viscose	51	53	50	55	70	87	91	91
Acetate	—	—	—	—	—	—	—	—
Sub-total	**51**	**53**	**50**	**55**	**70**	**87**	**91**	**91**
Synthetic								
Nylon	40	31	38	54	63	68	63	61
Polyester	185	187	240	297	293	332	400	450
Sub-total	**225**	**218**	**278**	**351**	**356**	**400**	**463**	**511**
Staple fibre								
Cellulosic								
Viscose	160	158	159	175	250	286	297	—
Acetate	—	—	—	—	—	—	—	—
Sub-total	**160**	**158**	**159**	**175**	**250**	**286**	**297**	**302**
Synthetic								
Polyester	134	136	139	180	181	218	270	—
Acrylic	42	47	—	—	—	—	—	—
Sub-total	**176**	**183**	**139**	**180**	**181**	**218**	**270**	**337**

provisional

Source

MoF. 1999. Economic Survey 1998/99 pp S-35 to S-36 New Delhi Ministry of Finance.

Table 12

Energy consumption in the textile industry: 1989/90 to 1996/97

Fuel	*1989/90*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Electricity (GWh)								
Textile	6886.1	7125.8	7213.5	7476.2	8004.7	8199.1	9378.7	—
Jute	690.0	722.0	713.3	781.2	741.8	787.0	855.4	—
Sub-total	**7576.1**	**7847.8**	**7926.8**	**8257.4**	**8746.5**	**8986.1**	**10234.1**	—
Coal (million tonnes)								
Jute	0.1	0.1	0.1	—	—	0.1	0.1	0.1
Cotton	2.7	2.6	2.0	1.9	1.8	1.8	1.2	1.3
Sub-total	**2.8**	**2.7**	**2.1**	—	—	**1.9**	**1.3**	**1.4**
* **Fuel oil (thousand tonnes)**	570.0	621.0	614.0	667.0	714.0	651.0	—	—

* includes furnace oil, low sulphur heavy stock and hot heavy stock.

Sources

1. CEA. Public Electricity Supply, All India Statistics, General Review (various issues). New Delhi: Central Electricity Authority.
2. MoC. Coal Directory of India (various issues). Calcutta· Coal Controller's Organization, Ministry of Coal.
3. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Industry (textiles)]

Table 13

Energy intensity of the textile industry

Product	*Electricity (kWh)*	*Coal (kg)*
Cotton (per metre)	0.9	0.8
Polyester (per metre)	—	1.3
Jute (per metre)	545.0	23.2

Source

Inter-Ministerial Working Group. Utilization and Conservation of Energy Sectoral Reports (various issues). New Delhi· Government of India.

Table 14

Power consumption (% of total) in different types of mills by section

Mill type	*Spinning preparatory*	*Ring frame*	*Weaving preparatory*	*Weaving*	*Humidification*	*Wet processing*	*Lighting*	*Others*
Spinning mills	21.0	55.0	4.5	—	14.0	—	3.5	2.0
Composite mills	12.5	29.3	5.0	12.8	18.5	10.0	4.0	7.9

Source

TERI. 1995. Sector Study Report on Energy Efficiency in the Indian Textile Industry. Submitted to the Industrial Credit and Investment Corporation of India, Mumbai. p.25 New Delhi: Tata Energy Research Institute. 58 pp.

Table 15

Specific electricity consumption in textile mills

Mill type and range	kWh/kg	kWh per spindle shift	kWh per loom shift
Spinning mills			
Maximum	6.6	0.4	—
Minimum	2.6	0.3	—
Average	4.6	0.4	—
Composite mills			
Maximum	19.5	1.1	103.0
Minimum	6.7	0.4	19.8
Average	13.1	0.8	35.3

Source

TERI. 1996. Sector Analysis: Textile Industry. Prepared for the Asian Development Bank Energy Efficiency Support Project. p 19. New Delhi· Tata Energy Research Institute. 34 pp.

Table 16

Growth of cement industry (million tonnes): 1985/86 to 1997/98

Item	1985/86	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
Capacity at the end of the year	42.35	56.96	59.12	61.31	64.94	71.26	78.09	86.76	96.25	100.30
Cement production	32.05	42.91	45.75	50.61	50.72	54.09	58.35	64.47	69.98	76.74
Growth (%)	—	2.80	6.60	10.60	0.20	6.60	7.90	10.50	8.50	9.52

Source

CMA. 1998. Basic Data of Indian Cement Industry 1997 New Delhi: Cement Manufacturers' Association.

For more details, please see TEDDY ONLINE+ [Section: Industry (cement)]

Table 17

Fuel consumption in the cement industry: 1989/90 to 1996/97

Fuel	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Electricity (GWh)	4206.6	4406.0	4574.0	4749.8	5569.9	5734.1	—	—
Coal (million tonnes)	9.5	10.4	10.8	11.7	11.1	12.4	11.1	10.1
Petroleum products (thousand tonnes)	246.0	271.0	293.0	296.0	291.0	346.0	514.0	549.0

includes high speed diesel, light diesel oil, furnace oil, low sulphur heavy stock and hot heavy stock

Sources

1 CEA. Public Electricity Supply, All India Statistics, General Review (various issues). New Delhi. Central Electricity Authority.

2 MoC Coal Directory of India (various issues) Calcutta: Coal Controller's Organization, Ministry of Coal

3. MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi· Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section Industry (cement)]

Table 18

Energy consumption norms for the cement industry

Process	Electrical (kWh/tonne of material)		Thermal (Gcal/tonne of clinker)
	Ball mill	*Roller mill*	
Limestone crushing	1–3	–	–
* **Raw material grinding**			
Dry	17–35	12–18	–
Wet	12–28	–	–
Coal grinding	25–35	20–25	–
Cement grinding			
Ordinary portland cement	35–40	–	–
Portland pozzolana cement	30–40	–	–
† Portland slag cement	55–60	–	–
Pyro processing			
Dry	30–35	–	0.85–1.00
Semi-dry	20–30	–	0.95–1.05
Wet	12–15	–	1.35–1.45

* wide range to account for the varying hardness of the material

† depending upon slag quantity

Source

NCCBM. 1989. NCCBM Norms for Cement Plant Operations. New Delhi: National Council for Cement and Building Materials. 46 pp.

Table 19

Specific energy consumption in the cement industry

Country and process	*Thermal (Gcal/tonne of clinker)*	*Electrical (kWh/tonne of cement)*
India		
Dry	0.9 *	122.1 ‡
Wet	1.4 †	108.8 §
Japan (1988)		
Dry	0.7	103.0
Germany (1990)		
Dry	0.8	108.0
Italy (1990)		
Dry	0.8	118.0
Wet	1.5	109.0
United Kingdom (1990)		
Dry	0.9	131.0
Wet	1.6	105.0
China (1990)		
£ Average for all plants	1.3	106.0

* weighted average of 15 units

† weighted average of 4 units

‡ weighted average of 29 units

§ weighted average of 10 units

£ China had nearly 61% wet process production in 1990

Sources

1 NCCBM, BICP 1994. Workshop on Assessment of Energy Use Pattern in Indian Cement Industry. New Delhi: National Council for Cement and Building Materials, Bureau of Industrial Costs and Prices. 92 pp

2 CEC 1993 Energy Technology in the Cement Industrial Sector Directorate General (DGE), XVII Brussels Commission of European Communities 208 pp

3. ECN. 1994 Cement in Development. Energy and Environment. The Netherlands: The Netherlands Energy Research Foundation 126 pp.

For more details, please see TEDDY ONLINE+ [Section: Industry (cement)]

Table 20

Finished steel production by producer (million tonnes): 1990/91 to 1996/97

Producers	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Main producers							
Bhilai Steel Plant	2.10	2.20	2.10	2.20	2.20	2.34	2.38
Bokaro Steel Plant	2.30	2.70	2.90	3.08	3.00	3.12	2.70
Durgapur Steel Plant	0.60	0.50	0.46	0.50	0.59	0.57	0.60
Rourkela Steel Plant	1.00	1.00	1.15	1.10	1.16	1.10	1.11
Sub-total SAIL (Steel Authority of India Limited)	**6.00**	**6.40**	**6.61**	**6.88**	**6.95**	**7.13**	**6.79**
Indian Iron and Steel Company Limited	0.24	0.32	0.32	0.25	0.28	0.27	0.28
Total (SAIL)	**6.24**	**6.72**	**6.93**	**7.13**	**7.23**	**7.40**	**7.07**
Visakhapatnam Steel Plant	0.02	0.25	0.54	0.67	0.97	1.34	1.45
Tata Iron and Steel Company Limited	0.93	0.99	0.94	0.97	1.37	1.79	1.98
Total (main producers)	**7.19**	**7.96**	**8.41**	**8.77**	**9.57**	**10.53**	**10.50**
Secondary producers	6.34	6.37	8.75	8.43	8.25	10.87	12.22
Total (finished steel)	**13.53**	**14.33**	**17.16**	**17.20**	**17.82**	**21.40**	**22.72**

Source

SAIL. 1998 Statistics for Iron and Steel Industry in India, 1998. p. 26 New Delhi: Steel Authority of India Limited.

Table 21

Production (million tonnes) of ingot steel: 1990/91 to 1996/97

Plant	*1990/91*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Bhilai Steel Plant	3.5	3.9	4.0	4.1	4.1	4.2
Bokaro Steel Plant	2.8	3.6	3.7	3.7	3.7	3.6
Durgapur Steel Plant	0.9	0.7	0.6	0.9	1.2	1.5
Rourkela Steel Plant	1.3	1.3	1.1	1.2	1.3	1.4
Indian Iron and Steel Company	0.3	0.4	0.3	0.3	0.3	0.4
Tata Iron and Steel Company	2.3	2.5	2.5	2.8	3	3.1
Visakhapatnam Steel Plant	0.1	1.1	1.2	1.7	2.1	3.2

Source

SAIL. 1998. Statistics for Iron and Steel Industry in India, 1998 p. 25. New Delhi: Steel Authority of India Limited.

Table 22

Crude steel production (million tonnes) by process: 1997

		Percentage of total		
Country	*Production*	*Basic oxygen furnaces*	*Electric arc furnaces*	*Open hearth furnaces*
India	23.7	53.3	31.6	15.2
Japan	104.5	67.2	32.8	—
European Union	159.8	63.2	36.8	—
North America	127.3	54.6	45.4	—
World	791.2	60.0	33.7	6.2

Source

SAIL. 1998 Statistics for Iron and Steel Industry in India, 1998. p. 489. New Delhi:
Steel Authority of India Limited

Table 23

Sponge iron production by producer (thousand tonnes): 1990/91 to 1996/97

Name of the unit	Location	Production						
		1990/91	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Coal-based								
Sponge Iron India Limited	Kothagudem, District Khamam, Andhra Pradesh	47	48	49	45	50	56	53
Orissa Sponge Iron Limited	Palaspanga, District Keonjhar, Orissa	80	100	94	105	94	99	92
IPITATA Sponge Iron Limited	Joda, District Keonjhar, Orissa	62	90	99	110	107	107	116
Bihar Sponge Iron Limited	Chandil, District Singhbhum, Bihar	112	123	118	125	143	131	147
Sunflag Iron and Steel Company Limited	Bhandara, Maharashtra	79	92	121	113	117	101	128
Jindal Strips	Raigarh, Madhya Pradesh	—	—	53	99	203	300	362
HEG Limited	Durg, Madhya Pradesh	—	—	—	60	59	61	61
Kumar's Metallurgical Corporation Limited	Malgonda, Andhra Pradesh	—	—	—	25	46	7	14
Bellary Steel and Alloys Limited	Bellary, Karnataka	—	—	10	30	45	53	53
Goldstar Steel and Alloys Limited	Vizianagaram, Andhra Pradesh	—	—	45	80	76	41	20
Prakash Industries Limited (commissioned in November 1993)	Champa, Bilaspur, Madhya Pradesh	—	—	—	65	148	147	190
Nova Iron and Steel Limited	Bilaspur, Madhya Pradesh	—	—	—	—	40	135	138
Raipur Steels and Alloys Limited	Raipur, Madhya Pradesh	—	—	—	25	27	48	69
Monnet Ispat Limited	Raipur, Madhya Pradesh	—	—	—	9	53	89	78
Tamil Nadu Sponge Limited	Salem, Tamil Nadu	—	—	—	5	7	7	8
Raigarh Electrodes Ltd	Madhya Pradesh	—	—	—	—	—	—	5
LLOYDS Metal & Engineers	Maharashtra	—	—	—	—	—	—	122
Rexon Strips Ltd	Orissa	—	—	—	—	—	—	12
Total		**380**	**453**	**589**	**896**	**1215**	**1385**	**1668**
Gas-based								
Essar Gujarat Limited	Hazira, Gujarat	450	828	915	1438	1326	1500	1547
Vikram Ispat Limited	Raigarh, Maharashtra	—	—	—	85	405	417	706
Nippon Denro Ispat Limited	Raigarh, Maharashtra	—	—	—	—	446	1105	1126
Total		**450**	**823**	**915**	**1523**	**2177**	**3022**	**3379**
Grand total		**830**	**1281**	**1504**	**2419**	**3392**	**4407**	**5047**

Note

The installed capacity during 1992/93 was 98 000 tonnes for coal-based plants and 800 000 tonnes for gas-based plants.

Source

SAIL. 1998 Statistics for Iron and Steel Industry in India, 1998 p 24 New Delhi Steel Authority of India Limited.

Table 24

Electricity generated, purchased, and consumed (GWh) in main steel plants: 1990/91 to 1996/97

Electricity and plants	*1990/91*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Generated						
Bhilai Steel Plant	675.7	806.3	778.0	759.6	800.2	814.9
Bokaro Steel Limited	1203.4	1315.2	1196.9	1243.4	1076.4	109.2
Durgapur Steel Plant	724.2 *	743.1 *	571.0	573.9	574.3	670.4
Rourkela Steel Plant	1002.0	1025.6	998.6	987.5	1011.7	1137.2
Indian Iron and Steel Company	122.3	112.4	124.9	119.1	104.4	115.1
Tata Iron and Steel Company	892.6	1081.0	1036.6	1104.2	1115.1	1103.7
Purchased						
Bhilai Steel Plant	1047.9	1048.0	1107.6	1173.1	1137.2	1131.0
Bokaro Steel Limited	648.0	774.0	1000.3	994.0	1160.7	109.3
Durgapur Steel Plant	36.9	48.9	99.5	195.7	277.4	250.4
Rourkela Steel Plant	202.5	207.4	252.1	291.2	321.4	299.1
Indian Iron and Steel Company	116.6	143.0	114.9	122.2	133.8	132.1
Tata Iron and Steel Company	533.4	507.8	730.4	865.7	1095.7	1210
Consumed						
Bhilai Steel Plant	1715.0	1845.8	1876.7	1922.3	1926.9	1935.5
Bokaro Steel Limited	1554.7	1765.1	1857.9	1848.3	1868.3	
Durgapur Steel Plant	385.4	394.3	437.7	564.7	624.5	689.9
Rourkela Steel Plant	1204.5	1233.0	1250.7	1278.7	1333.1	1436.3
Indian Iron and Steel Company	—	—	—	—	—	—
Tata Iron and Steel Company	1426.0	1588.9	1767.0	1969.9	2210.8	2313.6

* supplied to alloy steel plants

Source
SAIL. 1998. Statistics for Iron and Steel Industry in India, 1998. p. 303–304 New Delhi: Steel Authority of India Limited.

For more details, please see TEDDY ONLINE+ [Section: Industry (iron and steel)]

Table 25

Energy consumption per tonne in sponge iron plants

Fuel	*Coal-based*	*Gas-based*
Coal (tonnes)	1.2	—
Natural gas (m^3)	—	290.0
Electricity (kWh)	110.0	150.0
Light diesel oil (litres)	9.0	—
High speed diesel (litres)	3.5	—

Source

Chatterjee A 1988. A realistic assessment of the possibilities of direct reduction in India. Proceedings of the International Conference on Alternative Routes to Iron and Steel Under Indian Conditions. Organized by the Indian Institute of Metals and Tata Iron and Steel Company.

Table 26

Specific energy consumption (Gcal/tonnes) in crude steel production: 1992/93 to 1995/96

Producer	*Thermal*			
	1992/93	*1993/94*	*1994/95*	*1995/96*
Bhilai Steel Plant	8.7	8.9	8.9	8.9
Bokaro Steel Plant	10.1	10.0	9.6	9.7
Durgapur Steel Plant	16.9	18.4	14.6	11.8
Rourkela Steel Plant	12.6	14.3	14.9	14.5
Indian Iron and Steel Company Limited	33.6	36.6	35.2	34.1
Visakhapatnam Steel Plant	—	—	—	—
Tata Iron and Steel Company Limited	—	—	—	—

Source

Compiled by TERI, New Delhi.

Table 27

Installed capacity (million tonnes), production (million tonnes), and capacity utilization (%) in the paper industry: 1950/51 to 1994/95

Year	*Number of units*	*Installed capacity*	*Production*	*Capacity utilization*
1950/51	17	0.14	0.12	85
1960/61	25	0.40	0.35	86
1970/71	57	0.77	0.76	99
1980/81	135	1.65	1.11	67
1989/90	317	3.23	1.88	58
1990/91	325	3.30	2.06	62
1991/92	326	3.36	2.11	63
1992/93	340	3.55	2.13	60
1993/94	380	3.79	2.33	61
1994/95	380	3.95	2.51	64
1995/96	395	4.20	—	—
1996/97	398	4.30	—	—

Source

IAPMA. 1995 Status of Paper Industry. p.1. New Delhi: Indian Agro Paper Mills Association.

Table 28

Specific energy consumption in different process centres (mills) in the paper industry

Process	*Thermal (tonnes of steam per tonne of product)*		*Electrical (kWh/tonne of product)*	
	Indian	*International*	*Indian*	*International*
Digester	2.70 -3.90	1.90–2.30	58–62	43–46
Evaporator	2.50–4.00	1.80–2.20	—	—
Paper machine	3.00–4.00	1.80–2.00	465–475	410– 415
Soda recovery plant	0.50–1.10	0.30–0.50	170–190	127–135
Bleach plant	0.35–0.40	0.20–0.25	88–92	66–69
Deaerator	0.80–1.20	0.45–0.70	—	—
Stock preparation	—	—	275–286	164–172
Chippers	—	—	112–128	92–98
Washing and screening system	—	—	145–155	116–122
Utilities and others	—	—	248–252	160–165
Total (rounded figures)	**11.00–14.00**	**6.50– 8.50**	**1500–1700**	**1150–1250**

Source

DSIR. 1990. Technology Evaluation in Pulp and Paper Machinery Industry. New Delhi: Department of Scientific and Industrial Research

Table 29

Specific energy consumption norms for the pulp and paper industry

Type	*Purchased energy (million kcal/tonne)*	*Steam (tonnes/tonne of product)*	*Electrical (kWh/tonne)*
Writing and printing			
Integrated (wood pulp-based)	9.0	9.0	1400
Small and medium (agro-based)	8.7	5.8	1200
Small and medium (waste paper-based)	4.7	2.8	700
Kraft			
Integrated (wood pulp-based)	8.3	8.6	1280
Small and medium (agro-based)	5.5	4.1	650
Small and medium (waste paper-based)	3.7	2.3	550
Board			
Integrated (60% waste paper and 40% wood pulp)	7.5	7.0	1175
Medium (waste paper-based)	3.9	2.2	615
Small (waste paper-based)	4.3	2.4	685
Newsprint			
Large integrated	9.5 *	4.7	2230 *
Large integrated	7.5 †	—	—

* based on 100% wood pulp

† based on 100% bagasse

Source

Raghupathy S. 1994. Specific Energy Consumption Norms in Indian Pulp and Paper Industry. Paper presented at the Confederation of Indian Industry Energy Summit 94. Organized by the Confederation of Indian Industry (Southern Region), 25–27 August 1994, Chennai.

Table 30

Installed capacity, production, and capacity utilization in chlor-alkali industry: 1995/96 to 1997/98

Parameter	*1995/96*	*1996/97*	*1997/98*
Installed capacity (thousand tonnes a year)			
Caustic soda	1673.0	1914.0	2028.5
Soda ash	1690.0	1840.0	1895.0
Production (thousand tonnes a year)			
Caustic soda	1308.7	1320.0	1419.5
Soda ash	1603.0	1615.7	1626.8
Capacity utilization (%)			
Caustic soda	78.2	69.0	70.0
Soda ash	94.9	87.8	85.8

Source

AMAI. Annual Report (various issues). New Delhi: Alkali Manufacturers Association of India.

Table 31

Specific energy consumption in different sections in soda ash industry

	Solvay process		*Dual process*	
Section	*Thermal (Gcal/tonne)*	*Electrical (kWh/tonne)*	*Thermal (Gcal/tonne)*	*Electrical (kWh/tonne)*
Manufacturing				
Limestone calcination	1.0	35	—	—
Salt purification	0.1	10	0.1	10
Calcination of sodium bicarbonate	1.0	35	1.0	35
Crystallization, drying, and purification	1.0	25	1.0	25
Ammonia recovery	0.6	10	—	—
Manufacture of ammonium chloride	—	—	0.0	200
Utilities and general requirements	0.1	185	0.1	330
Total	**3.8**	**300**	**2.2**	**600**

Source

DSIR, CIN 1994. Report on the Technology Evaluation in Caustic Soda and Soda Ash Industry.
New Delhi: Department of Scientific and Industrial Research

Table 32

Total energy consumption for manufacturing caustic soda lye (48.5%)

Power consumption (kWh)	*Diaphragm*	*Mercury*	*Membrane*
DC Power	2561	5946	2435
AC/DC losses	107	166	108
Auxiliary	457	320	264
Thermal energy for evaporation (equivalent electrical energy)	942	—	148
Total (kWh)	**4067**	**3422**	**2955**

Source

MoI 1994 Bureau of Industrial Costs and Prices (BICP) Report on Caustic Soda Industry.
New Delhi: Ministry of Industry.

Transport

Introduction

Transport plays a significant role in the overall development of the national economy. In India, the share of the transport sector in GDP (gross domestic product) in 1995/96 was 4.4% (120.88 billion rupees at 1980/81 prices) (Table 2). The contribution to real GDP by the transport sector has grown annually by 6.5% between 1980/81 and 1995/96. In 1980/81, the railways and road transport together accounted for 76% of the transport sector's share in the GDP. It increased to 83% in 1995/96 at constant 1980/81 prices. Of the total transport GDP during 1995/96, road transport contributed 67%, railways 16%, water transport 13%, and air transport 4% (Figure 1).

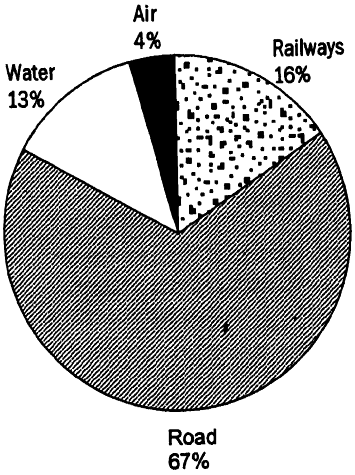

Figure 1 Contribution of various modes of transport to transport GDP in 1995/96
Source MoPPI (1998)

The transport sector in India is a major energy-consuming sector, particularly of oil. Almost half of the total petroleum products in the country are consumed by the transport sector in the form of HSD (high-speed diesel) and gasoline. Commercial energy consumption in this sector has increased at the rate of 3.1% a year between 1970/71 and 1980/81. It grew at a much faster rate of 4.9% a year between 1980/81 and 1990/91 and at 5.6% a year during 1990/91 to 1997/98. The higher rates of growth of energy consumption in the later period are primarily due to two structural shifts that have occurred in the transportation sector. The first is, India, a rail-dominant economy in the 1950s, has become a road-dominant economy in the 1980s. Railways, despite being a more energy-efficient mode of transport (Planning Commission 1980), are carrying a decreasing share in both freight and passenger movement. Second, the inadequate public transport system has led to an increase in the use of personalized mode of transport. As a result, personalized modes have an increased share in passenger traffic.

Roads

Road transport is the most dominant form of transport for people and goods in India. Over 80% of passengers and over 60% of freight are moved by roads (MoF 1999). Roads cater to all types of traffic. Long-distance traffic is served by national highways and state highways, inter- and intra-district traffic by major district roads, feeder traffic connecting rural centres of production to market outlets by other district roads, and local traffic by village roads and urban roads.

Rural roads need special mention. The Ninth Plan (1997–2002) identifies the construction of rural roads as a priority item to strengthen access to markets for the agriculture sector and the rural economy (Planning Commission 1999).

As on 31 March 1996, India has a road network of about 3.3 million km, which makes it the third largest road network in the world (MoST 1998).

About 55% of the road network is unsurfaced. While the aggregate length of roads has increased from 0.4 million km in 1950/51 to 3.3 million km in 1995/96, the existing road network suffers from inadequate pavement thickness and poor riding quality. Of this, the national highways comprised about 34 508 km. By the end of March 1998, 15 077 km more had been added to the national highway network (MoST 1999a).

The Sub-Group for the Ninth Five-Year Plan (1997–2002) has estimated that a sum of 745 billion rupees (at 1996 prices) will be required to address the deficiencies of the existing national highway network. In the long term, 15 766 km of expressway network would have to be added by the year 2020. Out of this, 4885 km would have to be added by 2005 on a priority basis (MoF 1999).

Thus significant investments will be required in this sector. However, unlike power and telecommunication sectors, which generate resources from user charges, the road sector in India has relied almost exclusively on funds provided through the budgetary process. Furthermore, there has been persistent underfunding in successive Five-Year Plans. Therefore, the critical issue to be tackled is the immediate implementation of a policy/regulatory framework to encourage private investment in roads as the scarcity of public funds calls for increased private participation.

This led to the amendment of the National Highways Act in 1995 to allow private sector participation. Several steps are being taken to initiate national highway projects through the private sector (Table 31). Liberalization of foreign investment norms in the road sector has resulted in the granting of automatic approval for foreign equity participation up to 100% in the construction and maintenance of roads and bridges up to a limit of 15 billion rupees. In the case of supporting services to land transport like operation of highway bridges, toll roads, and vehicular tunnels, the approval for foreign equity participation is up to 51% (MoF 1999).

In the public sector, funds have been made available to the NHAI (National Highways Authority of India) for its capital base, so as to enable it to leverage funds from the market. The Union Budget 1998/99 levied a tax of 1 rupee per litre of petrol. This is expected to yield 7900 million rupees which would be allocated to the NHAI (MoF 1999). In a continuation of this trend, a cess of 1 rupee per litre of HSD has been levied in the Budget 1999/2000. This is expected to yield 45 610 million rupees as additional excise duty and 3630 million rupees as countervailing duty on both imported and domestic HSD. Fifty per cent of this will be converted into a statutory cess and transferred to the central road fund, and 30% would be transferred to the state government for the development and maintenance of state roads. The remainder would be used for the development and maintenance of national highways and expressways and the Ministry of Railways for the construction of railway overbridges and safety works at unmanned crossings.

Passenger traffic

Roads have always catered to higher volume of passenger traffic than railways (Table 13). However, there has been a significant shift from the mid-1980s. In 1996/97, 80% of the passenger traffic was carried by roads as compared to 67% in 1970/71. This shift has manifested itself in the increasing number of vehicles on roads and a higher rate of utilization of these vehicles.

The disturbing trend here is that just 23 metropolitan cities account for over 10 million vehicles in the country. Thus a third of the total vehicle fleet caters to only 8.37% of the country's population. This has severe environmental and health impacts for urban areas.

The present situation can be explained to a great degree by the unsatisfactory performance of the public transportation system. Public transport has not been able to keep pace with the growing travel demand resulting in the usage of more personalized mode of transport. This is corroborated by the phenomenal increase in the registration of two wheelers and cars (Table 4). It is important to strengthen the public transportation system. The details of selected physical performance indicators of government-run transport undertakings, the SRTUs (state road transport undertakings) are given in Table 7. The financial performance of SRTUs has remained unsatisfactory, especially in urban areas (ASRTU 1999). As also mentioned in *TEDDY 1998/99*, the major reasons for these losses are excess staff, the poor condition of fleet, uneconomical fares, and the time lag between cost increase and fare revision.

Secondly, the road infrastructure has not been able to cope with this upsurge in traffic in urban areas. Road space cannot be augmented at the same rate as vehicle fleet. Transport management has been characterized by poor integration of transport and land-use planning (MoUAE 1988).

The increased number of private vehicles in the metropolitan cities has also resulted in higher fuel consumption and growing emissions from the transport sector. In view of the huge and mounting import bill of petroleum products, it is imperative to develop energy-efficient modes of public transport such as the mass rapid transit system.

Freight traffic

In freight traffic too, there has been a shift from rail to roads. However, the shift has been more dramatic here. From 34.5% in 1970/71, the share of road in freight movement has increased to 60% in 1996/97 (Table 13). Thus in relative terms, the shift has been much more significant than in the passenger traffic segment. This can be compared with the optimal share of roads in freight traffic of 28%–33% as recommended by the National Transport Policy Committee, 1980. The growth in freight traffic by roads is given in Figure 2. The Working Group on Road Transport for the Ninth Plan (1997–2002) has estimated the freight traffic by the end of the Ninth Plan to be in the range of 1276–1700 BT-km (billion tonne-kilometre) and 2054–3480 BT-km by the end of the Tenth Plan.

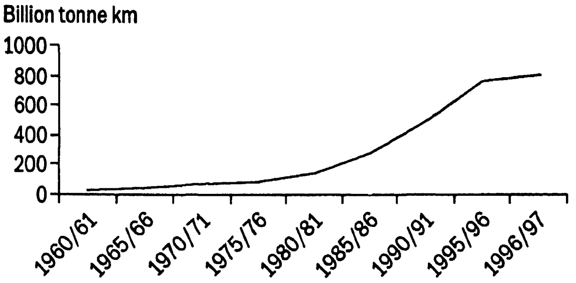

Figure 2 Growth in freight traffic by road
Source RITES (1998)

In India, road freight transport operations are almost entirely with the private sector. There is a two-tier structure prevailing in freight transport operations. The first tier is the large transport companies or agencies with more than three vehicles. The second comprises the smaller operators who actually carry the bulk of the freight. It has been estimated that 80%–90% of truck operators are small fleet owners (Planning Commission 1999a). Such a decentralized structure of operations makes it near impossible to achieve the objectives of energy conservation and environmental protection by command measures.

The commercial fleet utilization has not been satisfactory due to outdated technology, poor road infrastructure, overloading, and weak enforcement to check overloading (Planning Commission 1999).

Review of the Eighth Plan (1992-97)

The emphasis of the Eighth Plan was to speed up the completion of the ongoing road construction projects to avoid spillovers to the next plan. The focus was on externally-aided projects. Consequently, other highway projects suffered. Four and two laning of single lane stretches and the construction of bridges and bypasses received greater attention. The targets and achievements of the central sector roads are given in Table I.

Table I Eighth Plan targets and achievements in the roads sector

Scheme	*Target*	*Achievements*
Widening to two lanes (km)	1094	901
Widening to four lanes (km)	615	245
Strengthening weak two lanes (km)	3445	3542
Bypasses (no.)	14	9
Major bridges (no.)	73	37
Minor bridges including ROB (no.)	326	264

Source Planning Commission (1999a)

The Eighth Plan saw a shortfall in expenditure as compared to the outlay in the road transport sector. Against an outlay of 2640 million rupees, the expenditure was only 801.6 million rupees. This is because of the discontinuation of capital contribution to the SRTUs from 1993/94 onwards (an expenditure of 271.4 million rupees against an outlay of 700 million rupees) and the transfer of Delhi Transport Corporation to the Government of National Capital Territory, Delhi in August 1996 (194.3 million rupees against an outlay of 1400 million rupees). Expenditure under all other heads also fell short of the outlay.

Objectives of the Ninth Plan (1997-2002)

According to the Ninth Plan, over 81% of the investment requirement of the transport sector other than rail transport would come from private investment (Planning Commission 1999a). The Ninth Plan Executive Summary identifies dedicated levies and user charges, use of land development, and tax concessions as sources of private investment. The outlay and the requirements are given in Table II.

Table II Investment needs and sources in the Ninth Plan (billion rupees)

	Investment requirement	*Projected private*	*Public**		*Additional requirement*
			Centre	*States*	
Transport other than railways	1390	1131	396	395	–532

* public investment by the centre and states includes investment by the respective public sector enterprises

Source Planning Commission (1999b)

The objectives of the Ninth Plan are listed below.

- The highway network will be both expanded and improved to facilitate adequate, smooth, and safe transport of goods and people. The necessary resources will be generated through the levy of user charges and through private investment within an appropriate regulatory framework. Wherever necessary, the involvement of the state will be continued and strengthened.
- Special attention will be paid to the non-mechanized modes of transport to meet the mobility needs of people in an affordable and environment-friendly manner.
- Modernization of truck fleet is proposed either by way of design improvements or by promoting the use of multi-axle vehicles. Also, the efficient utilization of the commercial vehicle fleet is to be promoted by rationalizing the Motor Vehicle Tax and effective enforcement.
- Efforts will be made to tackle the problem of metropolitan transport both by managing demand through suitable price and non-price mechanisms and by improving the supply of public transport.
- Strengthening the public transport system in a phased manner to reduce personalized vehicles on the roads. There is a shift in emphasis in favour of private operators to meet the growing travel demand. Priority will be given to acquisition of buses for replacement. The state governments have been advised to meet incremental traffic demands through the private operators. However, the private sector operations have been unsatisfactory as most of the operators are small and are guided by the short-term maximization of profits. Thus it sought to organize this segment on sound corporate lines.

Railways

The Indian Railways is the second largest in the world under single management. It consists of an extensive network of routes spread over 62 500 km as on 31 March 1998. The broad gauge, which is about 69% of the total route-km, accounts for 97% of the freight tonne-km and 91% of the total passenger-km. The metre gauge caters to 2.3% of the freight movement and 8.5% of the passenger movement. The narrow gauge, constituting six per cent, has an insignificant share in the total traffic. The policy of unigauge would continue with the Ninth Plan (1997–2002). The electrified network has increased from 3706 km in 1970/71 to 13 490 km as on 31 March 1998, accounting for about 21% of the total route kilometreage. The Planning Commission recommended an accelerated plan for the electrification of railways and its implementation in a phased manner (MoR 1999).

The Railways is expected to operate on commercial lines while at the same time discharging the responsibility of a public sector undertaking. Thus in the face of a declining budgetary support to the Railways, it has increasingly taken recourse to the market. Market borrowings of the Railways were at 29.71 billion rupees in 1997/98, about 35% of the plan outlay (MoF 1999). This has put a constraint on the ability of the Railways to raise resources internally due to a rising interest burden, thus delaying some development projects. The options available for the Railways in such a scenario are limited. Passenger fares have been historically kept low by cross-subsidizing from the revenue from the freight business. However, this trend has been recognized as being unsustainable. Consequently, measures like the BOLT (build-own-lease-transfer) and the OYW (own-your-wagon) have been undertaken to encourage private sector participation as well as raise revenues for the Railways.

Despite being carriers of bulk commodities like coal, iron ore, and cement, the Railways has evolved marketing strategies to attract non-core piecemeal traffic. These include leasing of brake vans in mail/express and passenger trains, leasing of parcel vans, and containerization of wagonload and less-than-wagonload traffic.

The shift in traffic from rail to road is one of the major areas of concern for the Railways. As mentioned above, the share of the Railways has declined in both passenger and freight traffic. The Report of the NTPC (National Transport Policy Committee), 1980 says, 'we are concerned about our heavy dependence in transport on petroleum products – a non-renewable resource. It is suggested that the use of private cars and lorries should be discouraged and railways encouraged for energy conservation'. Additionally, the Railways is undertaking energy conservation measures by improving the specific energy consumption for traction. The use of fuel-efficient kits for diesel locomotives has also helped in reducing energy consumption. Also, the Indian Railways has the benefit of being environment friendly, and is an efficient land-use means of transport (MoR 1999a). The shift of freight movement from rail to road has taken place despite its advantages in terms of high speeds, bulk freight movement, carrying potential, economical land-use, etc. The reasons for this shift are given below.

- The planning process was based on the existing infrastructure and marginal improvements in productivity, rather than in relation to the projected economic growth.
- The budgetary support for the Railways has declined to 23% of the Railways Plan in 1997/98 from 75% in the Fifth Plan. The resultant market borrowing has put a constraint on the ability of the Railways to raise resources internally due to a rising interest burden, thus delaying development projects.
- The road sector has seen rapid growth with very little capital investment required from the government and the private sector investment is spread out over a large population.

In addition, the Indian Railways has an environment management policy that aims at phasing out diesel locomotives, eliminating the use of wooden sleepers, and afforestation on vacant lands of the Railways.

Passenger traffic

The passenger traffic by rail grew by more than three times from 1284 million to 4348 million between 1950/51 and 1997/98. During the same period, the travel demand increased more than six times from 66 517 MP-km (million passenger-kilometre) to about 379 897 MP-km.

As mentioned above, passenger travel has historically been cross-subsidized by freight traffic. Table III gives a comparison of average revenue per kilometre and total kilometres travelled between the freight and the passenger traffic for the financial year of 1997/98. As can be seen, although the passenger-kilometres is more than the tonne-kilometres for the freight, the earnings per kilometre from the freight are much more. The Railways classifies these as losses under 'social obligation costs'.

Table III Earnings from freight and passenger traffic per kilometre

	Revenue/km (paise)	*Total km*
Freight	68.9	286771
Passenger	19.9	379897

Source MoR (1999a)

Freight traffic

There has been a rapid growth in freight traffic carried by the Railways over the years, from 88 BT-km in 1960/61 to 280 BT-km in 1997/98. This is also reflected by the corresponding increase in the freight revenue, from 6180 million rupees in 1970/71 to 19 595 million rupees in 1997/98 (Table 10). However, the revenue in 1996/97 has fallen short for the Eighth Plan (1992–97) by about 44 million tonnes. Also, the freight traffic during April–November 1998 was 2.2% less than the freight traffic in April–November 1997 (MoR 1999). The *Economic Survey 1998/99* attributes this trend to the slowdown in industrial production and economic activity in general.

The Railways is a major carrier of bulk commodities like coal, iron-ore, cement, and POL (petroleum, oil, and lubricants). The increase in freight traffic between 1995/96 and 1996/97 has mainly been due to coal, cement, fertilizers, etc., whereas there has been a major shortfall in foodgrains, POL, finished steel from steel plants, and raw materials for steel plants (Table IV).

Table IV Revenue earning freight traffic (million tonnes)

Commodity	*1996/97*	*1997/98*	*Change over the previous year*
Coal	42.90	44.86	4.50%
Ores	6.53	7.04	7.80%
Foodgrains	14.00	10.89	-22.20%
Mineral oils	6.70	6.92	3.20%
Cement	6.96	7.37	5.90%
Fertilizers	6.56	7.74	17.90%
Iron and steel	4.64	4.40	-5.10%
Other goods	11.71	10.78	-7.90%

Source MoR (1999)

Review of the Eighth Plan (1992-97)

The main thrust in the Eighth Plan for the Railways was on capacity generation, besides rehabilitation and modernization, manpower planning and human resource development, energy conservation, safety, financial viability, and customer satisfaction through reliable and better quality of services. The output performance of the Railways during the Eighth Plan is summarized in Table V. As can be seen from Table V, there is a considerable shortfall compared to the targets set both in respect of freight movement and passenger traffic. However, the Ninth Plan document ascribes that to the sluggish growth in the economy in 1992/93 and 1993/94.

A promising development in the Eighth Plan was the performance of the CONCOR (Container Corporation of India) Limited. The CONCOR handled 96 000 TEUs (twenty-feet equivalent units) of the international container traffic at the beginning of the Eighth Plan and reached a level of 400 000 TEUs in 1996/97. The Eighth Plan also saw the long broad gauge project, the Konkan railway project, nearing completion. This project, unique in technical complexity and financing arrangements involving four beneficiary states, will accelerate the socioeconomic development of the Konkan region on the western coast.

Table V Eighth Plan targets and achievements of the Railways

Output	*Eighth Plan targets*	*Achievements*	
		1995/96	*1996/97*
Freight traffic (BT-km)	313.80	270.49	277.57
Passenger traffic (BP-km)	377.74	342.00	357.01

Source Planning Commission (1999a)

Objectives of the Ninth Plan (1997-2001)

The main thrust of the Ninth Plan would be on strengthening the capacity of the Indian railway system as a prime carrier of the long distance bulk freight and passenger traffic. To achieve these objectives, the thrust areas are given below.

- Generation of adequate rail capacity for handling the increasing freight and passenger traffic, with special emphasis on the development of terminals.
- Modernization and upgradation of the railway transport system to reduce costs and to improve reliability, safety, and quality of service to customers.
- Continuation with the policy of unigauge.
- Expansion and upgradation of inter-modal operations including containerization.

Civil aviation

Infrastructural facilities in the civil aviation sector are provided by the AAI (Airports Authority of India). This was formed by the merger of IAAI (International Airports Authority of India) and the NAAI (National Airports Authority of India) on 1 April 1995. The AAI is responsible for the maintenance of 87 domestic and 5 international airports in the country. In addition, it is also responsible for the management of 28 civil enclaves at the defence airports.

The upgradation of facilities available in the airports has received considerable attention in the post-liberalization era. A taskforce has been set up under the Chairmanship of the Deputy Chairman of the Planning Commission to identify locations for developing world-class international airports. The taskforce has recommended that the existing airports at Delhi and Mumbai and the proposed airport at Bangalore be corporatized immediately. Also, keeping in mind the social obligations of this sector and the importance of providing reliable service to the north-eastern states, the Ninth Plan (1997–2002) has recommended a daily connection to each of the seven states. Development programmes have been planned for the 20 airports in this region.

There have been notable changes in the operational side of this sector also. Till very recently, the state-owned Indian Airlines and Vayudoot were providing the domestic air services. The Air India and the Indian Airlines were providing international services. Since the repeal of the Air Corporation Act (1953) in March 1994, seven private operators, which were hitherto operating as air taxis, had been granted scheduled airlines status. As of now, in addition to the two scheduled private airlines, 31 air taxi operators have been given permits for charter/non-scheduled air transport services. The Vayudoot had since been merged with the Indian Airlines. Also the Indian Airlines and the Air India have been registered as companies. Additionally, the state-owned Pawan Hans Ltd provides helicopter support services primarily to the petroleum sector and remote areas of the north-eastern region of the country.

In view of the continuing poor financial performance of the two state-owned airlines, a number of initiatives have been undertaken. For the Air India, the Disinvestment Commission has recommended an infusion of government equity of 10 billion rupees and finally, to bring down the government's shareholding in the Air India to 40%. The Indian Airlines has focused on human resource development initiatives along with higher utilization of their fleet to raise their operational efficiency (MoCA 1999).

In April 1997, a new policy for private sector participation in the domestic air transportation sector was unveiled. It permits 100% NRI/OBC equity in domestic airlines. Foreign equity participation has been limited to 40%. However, equity participation by foreign airlines has not been permitted (MoF 1999).

The regulatory functions for this sector are performed by the DGCA (Directorate General of Civil Aviation) and the BCAS (Bureau of Civil Aviation Security).

Passenger traffic

The total number of passengers carried by private airlines has increased dramatically from 15 000 in 1990 to 4.26 million in 1997. Nearly 37% of the domestic air traffic is being catered to by the private airlines (MoF 1999). However, even with the entry of private airlines and air taxi operators, the Indian Airlines has retained its principal position. In 1998/99, it carried 6.058 million passengers (Table 26) despite having a negative growth in both capacity and traffic during the Eighth Plan. However, its financial position is disturbing. The Indian Airlines incurred a loss of 347 million rupees between April and October 1998 despite managing a profit of 473 million rupees in the last financial year after continuous losses in the previous eight years (MoF 1999). As a result, the net profit target has been revised to 200 million rupees for 1998/99. This downtrend has been ascribed to sluggish market growth.

The number of passengers carried by the Air India increased by 2.7% between 1996/97 and 1997/98 as compared to a growth rate of 4.8% a year between 1987 and 1994 (Table 27). During the same period, the foreign carriers have grown at a much faster rate. This has resulted in a decline in the share of the Air India in the international passenger traffic from 32.8% in 1980 to 21.3% in 1997 (Planning Commission 1999a). The loss reported in 1997/98 was 1810 million rupees, 1159 million rupees less than that in the previous year. However, the provisional losses for April–December 1998/99 have increased to 1997 million rupees (MoCA 1999). The causes identified for this loss were increased international competition and higher operational expenditures along with the depreciation of the rupee.

Freight traffic

The net tonne-km available with the Indian Airlines has risen from 1075.238 million in 1996/97 to 1094.132 million in 1997/98. Correspondingly, the RT-km (revenue tonne-kilometre) has risen from 698.116 million rupees to 700.896 million rupees in the same period. However, this is expected to fall to 697 million rupees in 1998/99 (Table 26). Again this has been attributed to the sluggish market (MoCA 1999). To counter this trend, a 'time-sensitive' courier service has been introduced. Also productivity-linked incentive schemes for cargo agents have been introduced.

The tonne-cargo availability has shown a declining trend for the Air India for the past three years (Table 26). It decreased from 2610.4 MT-km in 1995/96 to 2452.1 MT-km in 1996/97, and further to 2293.7 MT-km in 1997/98.

Review of the Eighth Plan (1992-97)

The Eighth Plan saw a complete overhauling of this sector. Against an outlay of 3.99 billion rupees, an expenditure of 7.094 billion rupees was undertaken. The bulk of the expenditure (98.76%) was financed through internal and extra-budgetary resources. The plan expenditures of the Indian Airlines and the Air India were completely financed through their own resources. The details of the outlays and expenditures are given in Table VI.

Table VI Eighth Plan outlay and expenditure (million rupees)

Organization	Outlay	Expenditure
Air India Ltd	18000	38865.3
Indian Airlines	12200	15556.6
Vayudoot	50	5.0
Pawan Hans	800	499.0
Airports Authority of India	8000	14965.0
Directorate General of Civil Aviation	250	142.3
Bureau of Civil Aviation Security	100	11.5
IGRUA (Indira Gandhi Rashtriya Udan Academy)	450	34.3
Hotel Corporation of India	100	886.8
Aero Club of India	30	0.0

Source Planning Commission (1999a)

Objectives of the Ninth Plan (1997-2002)

The Ninth Plan states that the primary objective would be to ensure healthy competition in the domestic air services sector, while providing adequate capacity. Also, the financial and technical health of the private sector operators would need greater attention to ensure reliable services. Finally, a proper environment would be created so that the state-owned domestic carrier (the Indian Airlines) can operate at full capacity while fulfilling its social obligations. This would be achieved by sharing the unprofitable routes between all the scheduled carriers.

Ports

There are 11 major ports and about 149 minor operable ports located along the 5560-km long coastline of the country. Against a capacity of 218 million tonnes on 31 March 1998, major ports handled 251.5 million tonnes as of end-March 1998 (Tables 18 and 19). Projections by the Ninth Plan (1997–2002) Working Group envisage a traffic of 424 million tonnes in 2002. On completion of the Eighth Plan (1992–97) spill-over schemes, the capacity would go up to 252 million tonnes. By the terminal year of the Ninth Plan, another 122 million tonnes would have been added. However, there would still be a shortfall of about 50 million tonnes. This is sought to be met by increases in productivity. On a longer-term perspective, the Rakesh Mohan Committee on Infrastructure and the Ministry of Surface Transport have made projections of 650 million tonnes in 2005/06 and 850 million tonnes in 2010/11, respectively.

Quite obviously, the port infrastructure needs significant capacity augmentation. In view of capacity constraints and growing congestion at major ports, it becomes vital to develop minor ports. For this purpose, the state governments and the Ministry of Surface Transport have formed the MSDC (Maritime States Development Council). This is expected to formulate an integrated policy for the ports sector, including minor ports.

The government's efforts will be supplemented by private efforts. Guidelines have been laid down for private sector participation in the ports sector. The following areas have been identified.

- Leasing of assets of port
- Construction and operation of container terminals, etc.
- Leasing of equipment for cargo handling and leasing of floating rafts from the private sector
- Pilotage
- Captive facilities for port-based industries

Moreover, automatic approval of foreign equity up to 100% has been permitted in the construction of ports and harbours. Support services to water transport such as the construction and maintenance of piers, loading, and discharging of vessels have been allowed automatic foreign equity participation approval up to 51%. All these measures are expected to yield about 80 billion rupees from the private sector (MoF 1999). In addition, the government has framed guidelines on joint-venture formation in major ports on 1 June 1998. There are 18 important schemes under various stages of implementation at various major ports by the private sector. In addition, nine projects have already been approved for private sector participation. These are listed in Table 32.

The increased privatization of ports, however, implies a gradual change in the role of port authorities and changes in attitude towards modernization and mechanization. Ports are governed currently by the Indian Ports Act (1908) and the Major Port Trust Act (1963). These acts have enough flexibility to allow privatization of port activities. However, greater delegation of both administrative and financial powers to ports has to be seriously considered, if private participation is to be encouraged and sustained.

In pursuance of its liberalization policy and to promote healthy competition between port trusts and private operators, an independent authority for fixing and revising port tariff, the Tariff Authority for Major Ports, was set up on 10 April 1997 with an amendment to the Major Port Trust Act, 1963.

Finally, the Empowered Committee on Environmental Clearance has been formed and transparent and simplified guidelines have been issued. This is expected to quicken the process of environmental clearance while balancing the goals of environmental protection and development.

Passenger traffic

Ports have never had a large share of passenger traffic. The number of passengers at major ports has risen from 156 000 in 1990/91 to 277 000 in 1996/97. The 179 minor ports handled 15.15 million passengers in 1996/97 as against 14.16 million passengers in 1990/91 (MoST 1999a).

Freight traffic

The major ports handled a total traffic of 251.5 million tonnes in 1997/98. Between April and December 1998, they handled 184.3 million tonnes as against a target of 190.07 million tonnes. Major increase in traffic was observed with respect to food grains (26.7%), other liquids (33.3%), and containerized cargo (19.1%). A composite view of the total traffic handled at the major and minor ports of the country during the past six years is presented in Table VII. As mentioned above and from Table VII, the share of minor ports in the cargo handled has been rising steadily. The shares of major commodities handled at major ports are as follows: POL (41%), iron ore (16%), fertilizers and raw materials (4%), coal (16%), and others (14%).

Review of the Eighth Plan (1992-97)

The traffic handled at major ports increased at a rate of 7.3% a year during the Eighth Plan. The commodities of note here were POL, which registered a decline in terms of the share in total traffic handled, and container traffic, which has shown a remarkable growth potential. The share of POL in the total traffic has declined from 44.3% in 1992/93 to 43.16% in 1996/97. The container traffic accounted for nearly 4.58% of the total traffic handled by ports in 1992/93, which increased to 9.06% in 1996/97.

Table VII Cargo traffic handled at major and minor ports in (thousand tonnes)

Year	*Minor ports*	*Major ports*	*Total*
1990/91	12.78	151.67	164.45
1991/92	13.26	156.64	169.90
1992/93	15.41	166.50	181.91
1993/94	19.45	179.02	198.47
1994/95	22.17	195.89	218.06
1995/96	25.82	215.21	241.03
1996/97	27.00	227.26	254.26
1997/98	34.60	251.44	286.04

Source MoST (1999a)

However, there has been a consistent underutilization of Plan allocations in this sector (Figure 3). During the Eighth Plan, an outlay of 32.16 billion rupees was approved for the ports sector. The actual expenditure was 19.07 billion rupees, out of which major ports accounted for 17.41 billion rupees. In respect of major ports, there has been a heavy shortfall in expenditure as compared to the outlay during the Ninth Plan (1997–2002). The main reasons for this are: (1) the delays caused in sanctioning the schemes, (2) slow progress of work by contractors, (3) adverse weather conditions, (4) contractual disputes, and (5) deferment of project schemes.

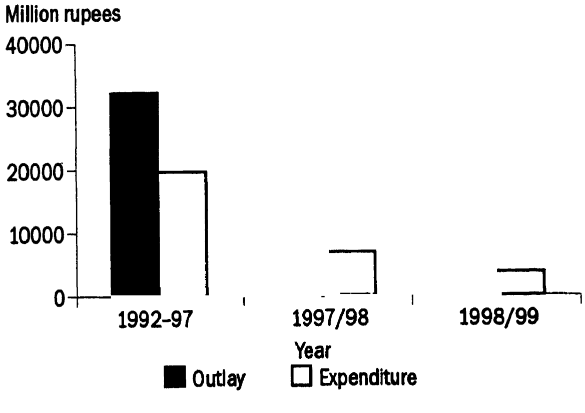

Figure 3 Plan outlay and expenditure in the ports sector
Source MoST (1999a)

Objectives of the Ninth Plan (1997-2002)

The operational strategy for the Ninth Five-Year Plan is to update the port infrastructure with expansion in traffic, including the size of the ships, specialization, and automation. The port capacities would need to be adequately augmented in view of the projected traffic during the Ninth Plan with larger private sector participation and development of selected minor ports. The traffic projections for commodities (for 2001/02) are given in Table VIII.

Table VIII Traffic projections by commodity for 2001/02 (million tonnes)

Commodity	*Estimated throughput*
POL.	186.7
Iron ore	34.4
Coal	93.7
Fertilizers	14.2
Containers	38.7
Other general cargo	56.2
Total	423.9

Source Planning Commission (1999a)

In order to decongest the major ports, the capacity of major ports is proposed to be augmented to 424 million tonnes a year by 2001/02 from the existing 215 million tonnes a year with an outlay of 80 billion rupees. This is in addition to the 80 billion rupees that is sought to be raised from the private sector.

Shipping

The Indian shipping industry has the largest merchant shipping fleet among the developing countries and ranks seventeenth in the world in shipping tonnage. There are 80 shipping companies in India. Of this, 10 private companies accounted for 31.5% of the total tonnage of 6.79 million GRT (gross registered tonnage) in September 1998 (MoST 1999b).

The largest company is the government-owned SCI (Shipping Corporation of India). It owns 116 ships with a tonnage of 2.986 million GRT in 1997/98. Its financial position showed a downtrend in 1996/97. The net profit of 3.23 billion rupees in 1995/96 came down to 2.33 billion rupees in 1996/97. However, it showed an improvement in the net profit in 1997/98 to the tune of 130 million rupees.

The Indian fleet is overaged. Over 64.9% of the fleet is over 10 years old. Consequently, the acquisition of certain categories of vehicles was put on the OGL (Open General Licence) in 1997.

The share of Indian shipping in India's overseas trade has been continuously declining. This is despite achieving an average export growth rate of 18% a year during the Eighth Plan (1992–97). In 1997/98, only 31.4% of the total overseas cargo of 202.44 million tonnes was handled by Indian liners. This can be compared to the peak of 41% in 1987/88 (Planning Commission 1999a). During this period, the share of Indian vessels in liquid bulk was 62.3%, in dry bulk it was 14.4%, and in liner traffic 12.4%. This has been attributed to the stagnating fleet strength (MoF 1999). Long-term targets for Indian shares in bulk carrier and liner traffic are 50% and 40%, respectively (MoST 1999b).

Inland water transport

Currently, the two most commonly used mode of transportation, namely, rail and road, have been stretched to their limits. The bottlenecks in the transportation system are causing hindrances in achieving the targeted growth in economy, especially in the industrial sector. The IWT (inland water transport) offers considerable potential and immense economic benefits if necessary infrastructure is provided. The IWT is an energy-efficient and inexpensive mode of transport for bulk commodities originating and terminating on the water fronts. Therefore, the Government of India decided to give major thrust to the development of waterways. In pursuit of this policy, the following three waterways have been declared as national waterways.

- National Waterway No. 1 (1620 km). The Ganga–Bhagirathi–Hooghly river system connecting Haldia, Calcutta, Farakka, Semeria, Patna, Varanasi, and Allahabad
- National Waterway No. 2 (891 km). The Brahmaputra river connecting Dhubri, Tezpur, Guwahati, Dibrugarh, and Sadiya
- National Waterway No. 3 (205 km). The west coast canal system stretching from Kottapuram to Kollam, Champakkara canal, and Udyogmandal canal

In addition to this, the NTPC (National Transport Policy Committee) has identified seven more waterways with potential for declaration as national waterways. These are the Sunderbans, the Godavari, the Krishna, the Mahanadi, the Narmada, the Mandovi, the Zuari rivers, the Cumberjua canal in Goa, and the Tapi.

However, the IWT forms a very small part of the total transport network of the country (less than one per cent of the total cargo traffic) (Planning Commission 1999a). The main reason for the small share of IWT traffic is its spatial limitation. It is effective only where both origin and destination of cargo are located on riverbanks. Also, only 5685 km of the 14 544 km of navigable waterways is suitable for the operation of mechanized crafts. There are only 400 vessels with a total capacity of 600 tonnes in this sector. The potential for cargo movement by the national waterways is estimated to be 50 BT-km by 2005 compared to the current level of 1 BT-km (Planning Commission 1999a).

The IWT has been given priority from the Sixth Plan onwards. During the Eighth Plan, out of a total allocation of 2400 million rupees, only 639.4 million rupees was spent (Planning Commission 1999a). To boost the IWT, various subsidy schemes have been launched for the purchase of vessels as well as support from the centre to the states for various projects for the construction of terminals. Also, prospects of private sector participation in cargo movement and infrastructure development are being explored.

The primary objectives of the Ninth Plan to make IWT an acceptable mode of transport by reductions in time and costs, and improved reliability and safety. A modest target of 20 BT-km by the IWT mode is set for the Ninth Five-Year Plan. Outlay for the development of IWT during the Ninth Plan has been tentatively fixed at 4700 million rupees.

The CIWTC (Central Inland Water Transport Corporation) Limited was established as a Government of India undertaking in 1967 to look after the assets and liabilities of the River Stream Navigation Co. which was looking after IWT services on river Barak. The traffic carried by the CIWTC from 1981/82 onwards is shown in Figure 4. The disappointing trend in the cargo carried by the CIWTC can be contrasted with the reported steady increase in cargo carried by private operators in Goa and Calcutta (Planning Commission 1999a).

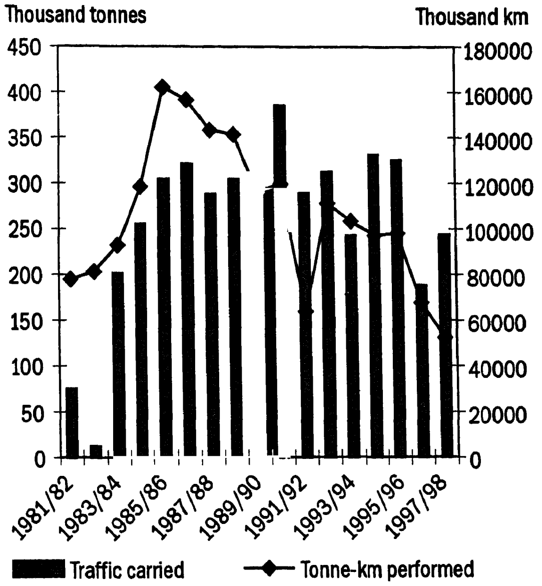

Figure 4 The Central Inland Water Transport Corporation traffic

Source MoST (1999c)

Containerization

The need to promote containerization has been spelt out in various policy documents. As evident from Table IX, there has been an increasing trend towards containerization since 1992/93, accounting for nearly 41% of the cargo traffic handled at the ports in 1996/97. While containerization has been increasingly adopted the world over, the process has been slow in India. The CONCOR provides multimodal containerized cargo handling and transport services. From about 155 000 TEUs handled in 1992/93, the traffic throughput has reached 722 000 TEUs, an almost five-fold increase in five years. The international streams between Tuglakabad to two ports and Mumbai, namely

Table IX Containerization of traffic at major ports (million tonnes)

Year	*Cargo traffic (non bulk)*	*Container traffic*	%
1990/91	27.12	7.7	28.39
1991/92	25.12	6.72	26.75
1992/93	28.51	7.62	26.72
1993/94	31.72	11.9	37.51
1994/95	39.37	15.01	38.12
1995/96	43.58	17.44	40.01
1996/97	47.21	20.74	43.93

Source MoST (1999a)

JNPT (Jawaharlal Nehru Port Trust) and MBPT, continued to be the most important rail-borne container traffic. On an average, two trains were run out to these ports every day in 1997/98, registering a six per cent increase in the number of container trains on these corridors over the previous year (CONCOR 1998).

The ICD (Inland Container Depot), Moradabad, was commissioned on 23 February 1998 as a road-linked facility. This ICD is also being developed for handling container trains. The ICD at Gwalior has been commissioned in June 1998. Work is also going on at Hyderabad, Dadri, Jaipur, and Cossipore.

Multimodal transport

In goods transport, the most important form of multimodal transport is containerization. With the spread of containerization worldwide, the concept of multimodal transportation is also developing rapidly. The Multimodal Transportation Act was enacted on 2 April 1993. On the basis of this, it would be possible to issue the combined transport document and to register multimodal transport operators. Thus multimodal transport operators can now provide one window service to the consignor/consignee for the movement of goods. A total of 172 multimodal transport operators have been registered (MoST 1999).

The Railways has identified multimodal transport as a technique to recapture its share in the general cargo traffic that it lost to the road sector (MoR 1993). The Railways can become the principal partner and a multimodal transport operator or just provide haulage on the rail portion. The efforts of the Railways in this regard have focused on raising the container traffic handled by the CONCOR.

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Table 1

Key data on transport: 1970/71 to 1997/98

Parameter	*Unit*	*1970/71*	*1980/81*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Railways											
Gross revenue receipts	million rupees	10069.5	27034.8	124515.5	141137.3	161147.3	183633.0	205291.1	228138.4	248013.1	291342.3
Route-length	km	59790.0	61240.0	62367.0	62458.0	62486.0	62462.0	62660.0	62915.0	62725.0	62495.0
of which:											
electrified	km	3706.0	5345.0	9968.0	10653.0	11064.0	11260.0	11772.0	12306.0	13018.0	13490.0
stations	number	7066.0	7035.0	7100.0	7116.0	7043.0	7050.0	7056.0	7068.0	6984.0	6995.0
Locomotives	number	11158.0	10908.0	8417.0	8268.0	7806.0	7220.0	6919.0	6909.0	—	—
Steam	number	9387.0	7469.0	2915.0	2492.0	1725.0	911.0	358.0	209.0	85.0	64.0
Diesel	*number*	1169.0	2403.0	3759.0	3905.0	4069.0	4192.0	4259.0	4313.0	4363.0	4496.0
Electric	number	602.0	1036.0	1743.0	1871.0	2012.0	2117.0	2302.0	2387.0	2527.0	2646.0
Passenger coaches	number	35145.0	38333.0	38511.0	39350.0	39924.0	40053.0	39214.0	39104.0	—	—
Electric multiple-unit coaches	number	1750.0	2625.0	3142.0	3366.0	3444.0	3537.0	3618.0	3691.0	3846.0	3971.0
Wagons	thousand	384.0	401.0	346.0	346.0	338.0	312.0	291.0	281.0	272.1	264.0
Number of employees	thousand	1374.0	1572.0	1652.0	1654.0	1646.0	1625.0	1602.0	1587.0	1584.0	1579.0
Average wage per employee	Rs	3398.0	8435.0	31864.0	35528.0	40466.0	45709.0	50777.0	59116.0	66645.0	89669.0
Passengers carried	million	2431.0	3613.0	3858.0	4049.0	3749.0	3708.0	3915.0	4018.0	4153.0	4348.0
Suburban passengers	million	1219.0	2000.0	2259.0	2412.0	2282.0	2302.0	2430.0	2484.0	2578.0	2657.7
Non-suburban passengers	*million*	1212.0	1613.0	1599.0	1637.0	1467.0	1406.0	1485.0	1534.0	1575.0	1691.0
Passenger-km	billion	118.0	209.0	296.0	315.0	300.0	296.0	319.0	342.0	357.0	380.0
Revenue-earning goods traffic	tonne	168.0	196.0	318.0	338.0	350.0	359.0	365.0	390.7	409.0	429.4
Net tonne-km	billion	127.0	158.0	243.0	257.0	258.0	257.0	253.0	273.5	280.0	287.0
Revenue-earning traffic	billion	111.0	148.0	236.0	250.0	252.0	252.0	250.0	270.0	277.6	284.2
Road											
Road length	thousand km	918.0	1485.4	2350.0	2485.8	2716.3	2919.4	2200.2	2403.6	—	—
Surfaced	thousand km	398.0	683.7	1112.5	1159.7	1283.3	1341.4	1216.3	1334.1	—	—
Unsurfaced	thousand km	520.0	801.7	1237.5	1326.1	1433.0	1578.0	1635.9	1069.6	—	—
Motor vehicles registered	thousand	1865.0	5391.0	21374.0	23507.0	25505.0	27660.0	30295.0	33783.0	37231.0	—
Ports											
Major ports	*number*	*10.0*	*10.0*	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Cargo handled at major ports	million tonne	55.6	80.3	151.7	156.6	165.9	178.1	197.3	215.3	227.3	251.5
Merchant shipping tonnage (gross registered tonnage) *by the end of December*	thousand	901.0	2500.0	6027.0	5939.0	6267.0	6329.0 *	6900.0 †	7020.0	—	—
Air traffic											
Indian Airlines											
Revenue passengers	million	2.1	5.4	7.9	8.9	7.8	7.9	7.6	7.7	8.2	8.4
Revenue tonne-km	million	200.0	400.0	699.2	761.0	685.3	695.2	686.3	722.8	765.2	827.5

* as on 30 November 1994

† as at the end of October

Sources

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For more details, please see *TEDDY ONLINE+* **[Section Transport (general)]**

Table 2

GDP (gross domestic product) in the transport sector (million rupees): 1980/81 to 1995/96

Item	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
At current prices								
Railways	11240	31360	64330	73420	84460	96480	112030	12580
Road transport	24540	69020	177900	222260	262670	296440	343970	382030
Water transport	8230	11910	23780	27320	32240	38490	45800	55060
Air transport	2550	5880	10650	12390	15800	17270	21800	25230
Total	**46560**	**118170**	**276660**	**335390**	**395170**	**448680**	**523600**	**474900**
GDP (%)	3.8	5.1	5.8	6.1	6.3	6.1	6.0	5.0
At constant (1980/81) prices								
Railways	11240	14040	16770	17780	17580	17460	17690	19060
Road transport	24540	38610	59980	63580	66890	70930	76300	81210
Water transport	8230	8430	10900	11330	11910	13160	14300	15610
Air transport	2550	3610	3850	3840	3590	3530	4220	5000
Total	**46560**	**64690**	**91500**	**96530**	**99970**	**105080**	**112510**	**120880**
GDP (%)	3.8	4.1	4.3	4.5	4.4	4.4	4.4	4.4

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For more details, please see TEDDY ONLINE+ [Section: Transport (general)]

Table 3

Petroleum, oil, and lubricants consumption (thousand tonnes) in transport: 1990/91 to 1993/94

	1990/91		*1991/92*		*1992/93*		*1993/94*	
Sector	*Consumption*	*Percentage to total*	*Consumption*	*Percentage to total*	*Consumption*	*Percentage to total*	*Consumption*	*Percentage to total*
High speed diesel								
Road transport	1864	8.8	1964	8.7	2057	8.4	2129	8.2
Aviation	11	0.1	11	0.1	12	0.1	17	0.1
Shipping	193	0.9	191	0.8	183	0.7	199	0.8
Railways	1453	6.9	1459	6.4	1417	5.8	1441	5.5
Other transport	15292	72.3	16657	73.4	18057	74.3	19273	74.5
Light diesel oil (regular)								
Road transport	1	0.1	1	0.1	1	0.1	1	0.1
Aviation	1	0.1	1	0.1	1	0.1	1	0.1
Shipping	67	4.5	61	4.2	66	4.7	65	4.8
Railways	4	0.2	3	0.2	2	0.1	2	0.1
Other transport	13	0.9	14	1.0	15	1.1	13	0.9
Fuel oil (regular)								
Road transport	45	1.0	8	0.1	7	0.1	7	0.2
Aviation	4	0.1	1	..	5	0.1	3	0.1
Shipping	300	6.7	245	5.0	235	4.4	292	5.8
Railways	22	0.5	21	0.4	15	0.3	16	0.3
Other transport	76	1.7	68	1.4	77	1.5	87	1.7

Table 3 Contd

Petroleum, oil, and lubricants consumption (thousand tonnes) in transport: 1994/95 to 1996/97

	1994/95		*1995/96*		*1996/97*	
Sector	*Consumption*	*Percentage to total*	*Consumption*	*Percentage to total*	*Consumption*	*Percentage to total*
High speed diesel						
Road transport	2156	7.6	2223	6.9	2224	6.3
Aviation	6	—	8	—	6	—
Shipping	207	0.7	203	0.6	240	0.7
Railways	1398	4.9	1410	4.4	1498	4.3
Other transport	20975	74.2	24190	75.0	26389	75.3
Light diesel oil (regular)						
Road transport	1	0.1	2	0.2	2	0.2
Aviation	1	0.1	1	0.1	1	—
Shipping	62	4.5	51	3.9	46	3.8
Railways	2	0.1	2	0.2	2	0.2
Other transport	17	1.2	12	0.9	15	1.3
Fuel oil (regular)						
Road transport	8	0.1	10	0.1	8	0.1
Aviation	3	0.1	2	—	3	—
Shipping	323	5.5	233	3.6	249	3.8
Railways	13	0.2	12	0.2	12	0.2
Other transport	93	1.6	64	1.0	79	1.2

including agricultural retail trade

Note

This table excludes consumption of motor spirit, which is, by and large, used for personalized transport

Source

MoPNG Indian Petroleum and Natural Gas Statistics (various issues) New Delhi Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 4

Registered motor vehicles (thousands): 1971 to 1997

Category	*1971*	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Two-wheelers	576	946	2117	5179	12611	14200	15661	17183	18899	20831	23252	25693
Cars, jeeps, and taxis	682	766	1059	1607	2694	2954	3205	3361	3569	3841	4204	4662
Buses	94	114	140	223	298	331	358	364	392	423	449	488
Goods vehicles	343	335	473	822	1238	1356	1514	1603	1691	1794	2031	2260
* Others	170	311	732	1339	2311	2533	2769	2994	3109	3406	3847	4128
All vehicles	**1865**	**2472**	**4521**	**9170**	**19152**	**21374**	**23507**	**25505**	**27660**	**30295**	**33783**	**37231**

* include tractors, trailers, three-wheelers (passenger and goods vehicles and other miscellaneous vehicles which are not separately classified)

Note

Figures pertain to 31 March of respective years.

Source

MoST.1999. Motor Transport Statistics of India, 1997. p. 1. New Delhi: Transport Research Wing, Ministry of Surface Transport. 103 pp. (For statistics beyond 1992.)

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 5

Registered taxed and tax-exempted motor vehicles (numbers) in metropolitan cities: 31 March 1997

City	*All vehicles*	*Two-wheelers*	*Three-wheelers*		*Cars*	*Jeeps*	*Taxis*	*Buses*	*Trucks*	*Tractors*	*Trailers*	*Others*
			Passenger	*Goods*								
Ahmedabad	631019	488547	35176	7419	65961	5812	3856	14640	8465	101	163	879
Bangalore	972375	707863	47957	13543	139649	6332	6023	13579	27096	4456	3952	1925
Bhopal	241773	173423	7539	2972	15509	16009	1111	4399	6661	8911	3411	1828
Calcutta	587576	261325	10007	—	217383	—	29008	7084	51300	4609	—	6860
Chennai	889819	652990	29578	3405	156521	6445	290	5198	21350	1061	1019	11962
Cochin	226185	136219	12978	16351	33028	3700	7247	3726	7769	469	985	3713
Coimbatore	255740	190465	5483	893	34219	2775	72	2138	10367	5481	1925	1922
Delhi	2847695	1876053	80210	—	705923	—	15015	29572	140922	—	—	—
Hyderabad	769401	668674	35642	14622	15425	8494	2034	2342	20319	187	—	1662
Indore	360549	266173	9122	4768	34494	3991	1139	6679	20903	6911	5052	1317
Jaipur	448625	331261	7602	—	38744	13886	3667	12386	22153	15377	2669	880
Kanpur	—	—	—	—	—	—	—	—	—	—	—	—
Lucknow	330753	263241	7719	2339	28174	8745	2591	1768	5117	7921	829	2309
Ludhiana	359228	309808	3872	5583	27949	1356	527	1125	8344	298	281	85
Madurai	122165	94560	3277	1820	8645	434	—	1864	6029	3203	856	1477
Mumbai	796913	328940	72007	27529	259536	20077	48646	12809	19529	1180	1148	5512
Nagpur	238576	187219	8082	6549	14669	4998	1495	2881	11480	292	494	417
Patna	—	—	—	—	—	—	—	—	—	—	—	—
Pune	476372	351538	32136	8081	40011	8428	2925	6918	24352	599	595	789
Surat	361838	308206	15627	3201	28522	2262	684	594	2148	118	174	302
Vadodara	332071	254772	17967	7428	33867	4887	2987	1995	4495	1109	2056	508
Varanasi	183925	142685	5754	1511	9230	5603	987	2387	7070	7162	767	769
Visakhapatnam	206834	173655	7171	1758	11419	1860	2066	1497	6490	175	119	624
All India	**11639432**	**8167616**	**454906**	**129772**	**1918878**	**126094**	**132370**	**135581**	**432359**	**69620**	**26495**	**45740**

Source

MoST. 1999. Motor Transport Statistics of India, 1997 p. 20. New Delhi. Transport Research Wing, Ministry of Surface Transport 103 pp.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 6

Buses owned (thousands) by public and private sectors: 1975 to 1997

Category	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Public sector	50.4	65.4	80.2	102.3	106.1	106.9	109.5	109.7	110.3	111.1	111.0
Private sector	63.2	74.9	143.0	195.7	225.0	251.3	271.5	309.1	314.6	338.7	377.1
Total	**113.6**	**140.3**	**223.2**	**298.0**	**331.1**	**358.2**	**381.0**	**418.8**	**424.9**	**449.8**	**488.1**
Nationalization (%)	44.4	46.6	35.9	34.3	32.0	29.8	28.7	26.2	26.0	24.7	29.4

held by state road transport undertakings

Note

Figures pertain to 31 March of respective years

Source

MoST 1999 Motor Transport Statistics of India, 1991 to 1997 p 6 New Delhi Transport Research Wing, Ministry of Surface Transport 103 pp.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 7

Utilization of fleet (for reporting state road transport undertakings): 1997/98

Description	*Rural*	*Hill region*	*Urban*	*Total*
Average buses held	94966.00	2890.00	13644.00	111500.00
Average buses off - Road	7251.00	504.00	1540.00	9295.00
Average no of spare buses	1317.00	12.00	324.00	1653.00
Average no of buses on road	86398.00	2374.00	11780.00	100552.00
fleet utilization (%)	91.00	82.10	86.30	90.20
Effective km (in million)	1014516.90	18130.10	96789.20	1129436.20
Dead km (in million)	16287.10	284.70	3073.90	19645.70
Gross km (in million)	1030804.00	18414.80	99863.10	1149081.90
Bus utilization per km (km)				
on buses on road	321.70	209.20	225.10	307.70
on buses held	292.70	171.90	194.40	277.50

Source

SRTU 1999 State Transport Undertakings *Profile and Performance 1997/98*. p 106.
New Delhi Association of State Road Transport Undertakings,

Table 8

Road accidents (thousands): 1970 to 1996

Items	*1970*	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996* *
Number of accidents	114.0	117.0	153.0	207.0	283.0	293.5	276.4	279.3	315.7	349.0	237.5
Persons killed	14.5	16.9	24.6	39.2	54.1	56.6	59.7	60.9	64.0	71.1	55.0
Persons injured	70.1	77.0	109.1	163.4	244.2	257.2	277.6	289.7	312.1	323.2	240.1
Vehicle population	—	2472.0	4521.0	9170.0	19152.0	21374.0	23507.0	25505.0	27660.0	30295.0	33783.0

provisional

Source

MoST 1999 Motor Transport Statistics of India, 1991 to 1997 pp 1, 5 New Delhi Transport Research Wing, Ministry of Surface Transport 103 pp

Table 9

Motor vehicle accidents (numbers) in metropolitan cities: 1994 to 1996

	1994			*1995*			*1996*		
City	*Number of accidents*	*Persons killed*	*Persons injured*	*Number of accidents*	*Persons killed*	*Persons injured*	*Number of accidents*	*Persons killed*	*Persons injured*
Ahmedabad	1814	142	1809	1971	173	2003	2573	215	2401
Bangalore	8198	587	6616	8677	678	6966	8474	715	6566
Calcutta	8124	507	2478	8895	480	2990	9294	474	3133
Chennai	4807	479	3553	5001	557	4326	5458	615	3783
Delhi	9050	1884	8927	10138	2074	9805	11315	2091	10558
Hyderabad	1930	337	1593	1983	347	1932	2034	342	2080
Indore	1886	133	1326	2181	158	1578	2354	174	1687
Jaipur	1617	265	1214	1738	280	1446	1922	263	1461
Ludhiana	208	146	76	219	143	101	256	162	142
Madurai	826	122	627	864	133	641	778	110	563
Mumbai	25214	319	6933	27564	387	6847	29808	405	7677
Nagpur	1216	152	920	1467	201	1133	1575	217	1207
Pune	2184	282	1829	2592	318	2222	2279	283	1980
Surat	1201	117	842	1483	159	1180	1379	133	1048
Visakhapatnam	949	158	731	832	154	687	773	158	760
All-India	**315657**	**64002**	**312080**	**349043**	**71140**	**323162**	**237541**	**55041**	**240139**

Source

MoST. 1999 Motor Transport Statistics of India 1997 p 29 New Delhi. Transport Research Wing, Ministry of Surface Transport 103 pp

Table 10

Railway traffic. 1970/71 to 1997/98

Traffic	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Passengers (million)												
Suburban	1219	1639	2000	1884	2259	2412	2282	2302	2430	2484	2578	2657
Non-suburban	1212	1306	1613	1549	1599	1637	1467	1406	1485	1534	1575	1691
Total	**2431**	**2945**	**3613**	**3433**	**3858**	**4049**	**3749**	**3708**	**3915**	**4018**	**4153**	**4348**
Revenue-earning goods traffic (million tonnes)	167.9	196.8	195.9	258.5	318.4	338.0	350.1	358.7	365.0	390.7	409	429
Gross earnings (million rupees)												
Passenger traffic	2960	5140	8270	17200	31470	36850	43150	48952	54588	61130	66161	75540
Goods traffic	6180	11510	16180	43760	84080	94620	106638	122755	134236	149728	163542	195950

Sources

1. MoR Indian Railways, Annual Report and Accounts (various issues) New Delhi. Railway Board, Ministry of Railways
2. MoR Indian Railways Yearbook (various issues) New Delhi Railway Board, Ministry of Railways

Table 11

Electrification of railway routes and tracks (km). 1970/71 to 1997/98

Routes/tracks	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Routes											
Electrified	3706	5345	6517	9968	10653	11064	11260	11772	12306	13018	13490
Total	**59790**	**61240**	**61836**	**62367**	**62458**	**62486**	**62462**	**62660**	**62915**	**62725**	**62495**
Running tracks											
Electrified	7447	10474	12367	18954	20049	20819	21223	21866	22684	24101	25238
Total	**71669**	**75860**	**77153**	**78607**	**78969**	**79200**	**79188**	**79495**	**80441**	**80754**	**80908**
Number of stations	7066	7035	7092	7100	7116	7043	7050	7056	7068	6984	6995

Source

MoR Indian Railways, Annual Report and Accounts (various issues) New Delhi Railway Board, Ministry of Railways

Table 12

Energy intensity in railways (consumption per thousand gross tonne-km): 1993/94 to 1997/98

Fuels	1993/94			1994/95			1995/96			1996/97			1997/98		
	Broad gauge	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*
Passenger and proportion of mixed															
Coal (kg)	92.4	89.6	91.5	98.0	92.5	95.4	129.4	90.6	95.3	—	81.7	85.0	—	75.2	82.2
Diesel oil (litres)	5.3	5.8	5.4	5.3	5.5	5.4	5.2	5.0	5.2	5.1	5.6	5.2	5.3	5.6	5.3
Electricity (kWh)	20.2	12.1	20.1	20.8	9.5	20.7	20.6	13.7	20.5	20.6	15.4	20.6	20.6	13.7	20.6
Goods and proportion of mixed															
Coal (kg)	111.2	108.9	110.2	109.1	134.9	133.1	—	62.1	62.4	—	238.0	240.0	—	382.4	381.6
Diesel oil (litres)	3.3	4.3	3.4	3.3	4.4	3.4	3.2	4.2	3.3	3.1	4.6	3.2	3.1	4.8	3.2
Electricity (kWh)	8.8	8.0	8.8	8.7	8.0	8.7	9.3	8.0	9.3	8.9	4.5	8.9	8.7	4.9	8.7

Source

MoR. Indian Railways, Annual Report and Accounts (various issues) New Delhi Ministry of Railways

Table 13

Trends in relative rail and road traffic: 1970/71 to 1996/97

Mode	*1970/71*	*1973/74*	*1976/77*	*1979/80*	*1982/83*	*1985/86*	*1988/89*	*1996/97*
Freight traffic								
Rail (%)	65.5	61.5	62.3	54.6	48.6	48.7	48.0	40.0
Road (%)	34.5	38.5	37.7	45.4	51.4	51.3	54.0	60.0
Total (billion tonne-kilometre)	**194.41**	**199.05**	**251.53**	**285.85**	**365.89**	**422.68**	**505.00**	—
Passenger traffic								
Rail (%)	32.9	31.6	29.7	27.9	23.7	22.2	23.0	20.0
Road (%)	67.1	68.4	70.3	72.1	76.3	77.8	77.0	80.0
Total (billion passenger-kilometre)	**359.05**	**427.60**	**549.33**	**710.40**	**955.90**	**1079.20**	**1169.00**	—

Sources

1 CMIE Basic Statistics Relating to the Indian Economy (various issues). Mumbai· Centre for Monitoring Indian Economy

2 MoR. 1998 Status Paper on Indian Railways New Delhi Ministry of Railways (For 1996/97)

3 MoF 1999 Economic Survey, Government of India, New Delhi Ministry of Finance

For more details, please see TEDDY ONLINE+ [Section Transport (general)]

Table 14

India's overseas sea-borne trade (thousand tonnes): 1992/93 and 1993/94

	1992/93			*1993/94*		
Total trade	*Indian*	*Foreign*	*Total*	*Indian*	*Foreign*	*Total*
Exports						
General cargo	1238.6	6861.5	8100 1	1030	14150	15180
Dry bulk	6220.1	29736.5	35956.6	5590	31680	37270
Petroleum, oil, and lubricants/other liquids	231.6	2824.6	3056.2	2380	5510	7890
Sub-total	**7690.3**	**39422.6**	**47112.9**	**9000**	**51340**	**60340**
Imports						
General cargo	1230.9	7810 5	9041.4	1260	9630	10890
Dry bulk	7572 6	15587 0	23159.6	5950	14440	20390
Petroleum, oil, and lubricants/other liquids	26165 4	16818.5	42983 9	29860	15490	45350
Sub-total	**34968.9**	**40216.0**	**75184.9**	**37070**	**39560**	**76630**
Grand total						
General cargo	2469 5	14672 0	17141 5	2290	23780	26070
Dry bulk	13792 7	45323.5	59116.2	11540	46120	57660
Petroleum, oil, and lubricants/other liquids	26397 0	19643.1	46040.1	32240	21000	53240
Total	**42659.2**	**79638.6**	**122297.8**	**46070**	**90900**	**136970**

Source

MoST. Annual Report (various issues). New Delhi. Ministry of Surface Transport

Table 15

Indian shipping gross registered tonnage (million): 1971 to 1998

Items	*1971*	*1981*	*1985*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998* *
Number of ships													
Coastal	62	65	95	151	162	169	187	202	206	219	231	232	243
Overseas	193	338	273	254	256	246	254	241	231	251	253	244	236
Total	**255**	**403**	**368**	**405**	**418**	**415**	**441**	**443**	**437**	**470**	**484**	**476**	**479**
Shipping Corporation of India	77	147	146	126	127	127	128	125	121	123	121	117	118
Gross registered tonnages (million)													
Coastal	0 2	0 3	0.3	0 5	0.5	0.6	0 6	0 6	0 7	0 7	0 7	0 6	0 6
Overseas	2.3	5 6	5 7	5 5	5 5	5 4	5 7	5 6	5 7	6 3	6 3	6 2	6 2
Total	**2.5**	**5.9**	**6.0**	**5.9**	**6.0**	**5.9**	**6.3**	**6.3**	**6.4**	**7.0**	**7.0**	**6.8**	**6.8**
Shipping Corporation of India	0.9	3 0	3 2	2 9	3 0	3 0	3 0	2 9	3 0	3.2	3.1	3 0	3 0

September

Note

Figures pertain to the end of the year or quarter

Sources

1. MoST. 1998. Handbook of Management and Information p 29. New Delhi: Transport Research Wing, Ministry of Surface Transport. 52 pp
2. MoST 1998. Indian Shipping Statistics p. 8 New Delhi: Transport Research Wing, Ministry of Surface Transport

Table 16

Water resources potential in the river basins of India (cubic kilometres)

River basin	*Average annual potential in the river*	*Estimated utilizable flow excluding groundwater*	*Present use of surface water (1989)*	*Present stage of utilization (%)*
Indus (up to 'border)	73.31	46.00	40.00	87.00
Ganga	525.02	250.00	—	—
Brahmaputra, Barak, and others	585.60	24.00	—	—
Godavari	110.54	76.30	38.00	50.00
Krishna	78.12	58.00	47.00	81.00
Cauvery	21.36	19.00	18.00	95.00
Pennar	6.32	6.86	5.00	73.00
East-flowing rivers between Mahanadi and Pennar	22.52	13.11	—	—
East-flowing rivers between Pennar and Kanyakumari	16.46	16.73	—	—
Mahanadi	66.88	49.99	17.00	34.00
Brahamani and Baitarani	28.48	18.30		
Subernarekha	12.37	6.81		
Sabarmati	3.81	1.93	1.80	93.00
Mahi	11.02	3.10	2.50	81.00
West-flowing rivers of Kachch, Saurashtra, including Luni	15.10	14.98	—	—
Narmada	45.64	34.50	8.00	23.00
Tapi	14.88	14.50	—	—
West-flowing rivers from Tapi to Tadri	87.41	11.94	—	—
West-flowing rivers from Tadri to Kanyakumari	113.53	24.27	—	—
Area of inland drainage in Rajasthan desert	—	—	—	—
Minor river basins draining into Bangladesh and Burma	31.00	—	—	—
Total	**1869.37**	**690.32**	—	—

Source

MoST.1999. Statistics of Inland Water Transport 1997/98. New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 17

Cargo carried and freight earned by the Central Inland Water Transport Corporation by commodity: 1993/94 to 1996/97

Commodity	*1993/94* Tonnes carried	*1993/94* Freight earned (million rupees)	*1994/95* Tonnes carried	*1994/95* Freight earned (million rupees)	*1995/96* Tonnes carried	*1995/96* Freight earned (million rupees)	*1996/97* Tonnes carried	*1996/97* Freight earned (million rupees)
Rice	26493	1487.00	—	—	7575	384.00	3311	190.30
Fertilizers	38707	1012.30	44558	1183.30	25039	606.50	2018	61.50
Tea	214	10.20	8	0.40	—	—	—	—
Cement	2919	111.20	4442	225.50	21401	699.40	12240	613.10
Coal	6640	220.50	2002	63.70	—	—	—	—
Jute	851	6 00	—	—	2200	134.30	420	16.80
Marble stones	531	21.90	—	—	—	—	—	—
Household goods	2	0 20	—	—	—	—	—	—
Personal effect	2	0 10	—	—	—	—	—	—
General cargo	11960	613.60	14797	759.60	23510	1614 20	170	909 20
Foodgrains	6990	293.30	21439	1346 30	5805	141.80	—	—
Stone chips	5748	131 70	5124	86.80	—	—	—	—
Fresh water	100	2 50	706	20.40	103	3.60	376	39 00
Pulses	—	—	—	—	1814	44 80	7500	203 20
Paper	—	—	2600	165 10	8073	243 20	5070	302 10
Mustard seed	—	—	924	25 40	—	—	—	—
Petroleum, oil and lubricants	122644	1165.30	197850	1979.50	201708	2238 90	103461	1206 00
Towing/hire/dentation charges additional freight	—	— 69.70	—	— 654 70	—	— 771 00	—	— 853 70
Godown Rent	—	—	—	309 10	—	—	—	—
Petroleum coke	15122	304 40	—	—	—	—	—	—
Sulphur	3543	74.40	1270	34.90	—	—	—	—
Wheat	—	—	—	—	3549	35 00	—	—
Wheat flour	—	—	—	—	3316	83 10	—	—
Sugar	—	—	19895	540.90	1300	29 30	—	—
Boulder	—	—	—	—	17082	369.30	19449	699.20
Other dry cargo	—	—	—	—	2809	951 50	7175	1824 80
Pig iron	—	—	2354	82 70	—	—	—	—
Rock phosphate cake	—	—	5000	137.50	—	—	5000	97.50
D Peas	—	—	4503	123.80	—	—	2367	92 50
Limestone	—	—	3461	74.60	—	—	70	11.30
Billet	—	—	—	—	—	—	1999	64 00
Total	**242466**	**5524.30**	**330933**	**7814.20**	**325254**	**8349.90**	**188440**	**7184.20**

Source

MoST. 1999. *Statistics of Inland Water Transport 1997/98* New Delhi Transport Research Wing, Ministry of Surface Transport

Table 18

Capacity available at major ports (million tonnes): 1992 to 1998

Commodity	*Eighth Plan target*	*31 March 1992*	*31 March 1993*	*31 March 1994*	*31 March 1995*	*31 March 1996*	*31 March 1997*	*31 March 1998*
Petroleum, oil and lubricants	106.15	78.00	78.00	78.00	78.00	80.00	94.92	96.92
Iron ore	42.50	41.50	41.50	41.50	41.50	41.50	44.50	44.50
Coal	42.00	7.00	7.00	8.00	8.00	8.00	9.00	9.00
Fertilizer	6.60	7.95	7.95	7.95	7.95	7.95	5.65	5.65
Container	17.33	6.83	8.38	8.62	8.98	8.98	13.91	61.59 †
General cargo	38.91	27.45	28.20	29.07	29.58	31.03	47.23	—
Total	**253.49**	**169.23**	**171.03**	**173.14**	**174.01**	**177.46**	**215.21**	**217.66**

includes other containers

Sources

1. GoI 1997 Annual Plan 1996/97 p. 367 New Delhi. Planning Commission, Government of India.
2. MoST. 1998 Handbook of Management and Information, p. 5. New Delhi. Transport Research Wing, Ministry of Surface Transport. 52 pp

Table 19

Cargo traffic handled (million tonnes) (commoditywise) at major ports: 1970/71 to 1997/98

Commodity	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Petroleum, oil and lubricants	18.89	33.58	54.89	64.00	67.60	73.76	76.92	80.37	90.92	98.08	104.03
Fertilizer raw material	2.27	6.20	6.81	8.94	9.92	9.91	9.47	11.00	12.36	7.18	9.85
Iron ore	19.20	22.84	28.84	31.73	31.60	29.83	34.10	34.35	34.56	33.05	39.23
Coal	0.68	2.11	7.54	19.66	22.40	24.49	26.81	30.80	33.79	34.87	39.39
Foodgrains	3.19	0.98	1.13	1.53	1.54	2.80	1.96	1.34	3.85	3.26	3.02
Others	11.34	14.56	16.23	18.11	16.86	18.65	17.86	23.02	22.29	30.23	32.85
Total	55.57	80.27	115.44	143.97	149.92	159.44	167.12	180.88	197.77	206.67	251.51
of which.											
unloaded	25.56	46.82	67.97	85.09	86.57	97.92	100.25	109.84	120.63	129.10	142.65
loaded	30.02	33.45	51.64	66.58	70.08	67.94	77.90	87.42	94.70	98.16	108.66

Note

Since 1989/90, fertilizer raw material includes liquid raw fertilizer also.

Sources

1. MoST 1995. Basic Port Statistics of India, 1994/95 p. 33. New Delhi Transport Research Wing, Ministry of Surface Transport. 196 pp.
2. MoST.1996. Basic Port Statistics of India, 1995/96. p. 5–6. New Delhi: Transport Research Wing, Ministry of Surface Transport. 263 pp.
3. MoST 1997. Basic Port Statistics of India, 1996/97. p. 6 New Delhi: Transport Research Wing, Ministry of Surface Transport. 263 pp.
4. MoST. 1998. Handbook of Management and Information p 1. New Delhi: Transport Research Wing, Ministry of Surface Transport. 52 pp.

Table 19A

Cargo traffic handled (thousand tonnes) (commoditywise) at minor ports: 1990/91 to 1996/97

Item	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Fertilizer and raw material	2.63	2.15	3.01	2.28	1.65	2.61	1.94
Iron and other ore	0.95	0.36	0.49	0.44	5.18	4.69	5.74
Oil cakes	1.71	2.07	2.37	2.48	2.15	2.04	2.20
Building material	1.86	1.80	1.53	1.55	4.04	4.10	4.14
Salt	0.17	0.17	0.17	0.25	0.18	0.17	0.26
Others	5.46	6.71	7.84	12.47	9.08	12.10	13.67
Total	**12.78**	**13.26**	**15.41**	**19.47**	**22.28**	**25.71**	**27.95**
Passenger traffic handled (million)	14.16	15.59	14.95	15.41	15.63	17.79	15.15

Source

MoST. 1999. Basic Port Statistics of India 1997/98. New Delhi Ministry of Surface Transport

Table 20

Commodity traffic at various ports (million tonnes): 1980/81 to 1996/97

Ports	Mineral oil and POL *		Iron ore		Coal		Fertilizers		Foodgrains		Other dry cargo		Total	
	1980/81	1990/91	1980/81	1990/91	1980/81	1990/91	1980/81	1990/91	1980/81	1990/91	1980/81	1990/91	1980/81	1990/91
Calcutta	5.20	7.26	—	—	0.88	4.11	0.60	0.60	—	—	2.48	2.78	9.27	14.95
Chennai	4.50	8.16	2.75	5.55	0.10	4.35	0.60	0.50	0.20	0.70	1.79	5.55	10.38	24.52
Jawaharlal Nehru Port Trust	—	—	—	—	—	—	—	0.50	—	—	—	0.66	—	2.02
Kandla	7.20	15.10	—	—	—	—	0.40	0.31	—	—	0.51	2.99	8.76	19.70
Kochi	4.00	5.80	—	—	—	—	0.60	0.20	—	—	0.60	0.57	5.23	7.28
Mormugao	0.60	1.40	12.60	13.00	—	—	0.20	0.20	—	—	0.40	0.21	13.76	15.10
Mumbai	9.00	19.67	—	—	—	—	0.73	0.50	—	—	6.62	7.94	16.98	28.90
New Mangalore	0.30	0.60	0.10	6.13	—	—	0.20	0.10	0.04	—	0.44	1.10	1.00	8.02
New Tuticorin	0.44	0.50	—	—	0.74	2.64	0.44	0.29	0.08	0.11	0.71	1.25	2.56	5.08
Paradip	—	—	1.82	1.75	0.07	3.61	0.10	0.10	—	—	0.26	0.90	2.24	6.88
Visakhapatnam	2.39	5.60	5.66	5.50	0.40	4.90	0.40	0.46	1.30	—	0.80	1.70	10.12	19.42

Ports	Mineral oil and POL		Iron ore		Coal		Fertilizers		Foodgrains		Other dry cargo		Total	
	1993/94	1994/95	1993/94	1994/95	1993/94	1994/95	1993/94	1994/95	1993/94	1994/95	1993/94	1994/95	1993/94	1994/95
Calcutta/Haldia	8.7	9.7	0	0	5.4	5.8	0.2	0.2	0.1	—	3.75	4.38	18.5	20.5
Chennai	9.1	11.9	4.5	5.1	5.9	6.4	0.9	0.8	0.1	—	5.8	4.7	26.5	29.5
Jawaharlal Nehru Port Trust	—	—	—	—	—	—	0.9	1.2	0.3	—	2.2	3.7	3.4	5.0
Kandla	18.2	18.9	—	—	—	—	0.8	0.7	0.6	0.7	3.8	5.0	24.5	26.5
Kochi	6.1	6.6	—	—	—	—	—	0.1	—	—	0.8	1.1	7.6	8.6
Mormugao	2.1	1.9	15.7	15.7	0.1	0.4	0.1	0.1	—	—	0.5	0.6	18.7	18.9
Mumbai	20.8	18.8	—	—	—	—	0.1	0.1	0.7	0.6	8.0	10.3	30.5	30.7
New Mangalore	0.6	0.7	5.8	7.1	—	—	0.1	0.1	—	—	0.8	0.7	7.1	8.6
New Tuticorin	0.5	0.4	—	—	3.9	4.5	0.2	0.2	—	—	1.9	2.4	6.7	8.0
Paradip	—	—	1.5	1.9	4.8	5.8	0.5	0.7	—	—	1.2	1.6	8.3	10.1
Visakhapatnam	7.5	11.2	5.2	5.6	6.6	7.8	0.7	0.8	—	—	4.4	3.3	25.6	30.0

Ports	Mineral oil and POL		Iron ore		Coal		Fertilizers		Foodgrains		Other dry cargo		Total	
	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97
Calcutta/Haldia	11.4	11.8	—	—	5.9	7.1	0.2	0.1	0.1	—	4.0	4.4	21.5	23.1
Chennai	11.6	12.4	4.9	4.7	7.5	8.8	1.0	0.5	0	0.1	5.4	5.6	31.0	31.8
Jawaharlal Nehru Port Trust	—	—	0.7	0.7	—	—	1.7	1.0	0.1	0.4	4.1	5.4	6.9	8.1
Kandla	21.1	25.1	—	—	—	0.1	0.7	0.4	2.0	2.0	5.4	5.0	30.3	33.7
Kochi	9.4	9.2	—	—	—	0.1	0.2	0.2	—	—	1.1	1.4	11.5	11.7
Mormugao	1.9	1.2	14.9	14.6	0.6	0.4	0.1	—	—	—	0.5	0.8	18.1	17.3
Mumbai	21.1	19.9	—	—	—	—	0.1	0.1	1.2	1.0	10.7	11.8	33.9	33.4
New Mangalore	1.0	5.1	6.1	5.9	—	—	0.2	0.2	—	0.1	0.9	0.9	8.0	12.5
Tuticorin	0.4	0.5	—	—	5.6	5.5	0.4	0.3	—	0.1	2.4	2.5	9.3	9.2
Paradip	1.1	1.7	1.7	1.4	5.9	6.5	0.1	0.1	—	—	1.5	1.2	11.3	11.6
Visakhapatnam	12.6	13.4	5.7	5.9	8.2	9.1	1.1	0.5	0.4	0.4	3.6	4.0	32.8	34.5

* POL - petroleum, oil and lubricants

Sources

1 Planning Commission 1994 Compendium of Transport Statistics pp 85–88 New Delhi Transport Division, Planning Commission, Government of India 141 pp

2 MoST Basic Port Statistics of India (various issues) New Delhi Transport Research Wing, Ministry of Surface Transport

Table 21

Growth of civil aviation: 1970/71 to 1997/98

Indicators	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Fleet strength (number)									
Indian Airlines	73	49	54	59	55	57	58	62	59
Vayudoot	—	— †	3	17	17	16	— ‡	— ‡	— ‡
Revenue tonne-km (million)									
Air India	275	980	1110	1381	1141	1091	1094	1385	1619
Indian Airlines	200	400	720	699	761	685	695	686	723
Vayudoot	—	—	7	20	19	11	— ‡	— ‡	— ‡
Number of passengers carried (million)									
Air India	0.5	1.4	1.8	2.2	2.0	2.2	2.0	2.5	2.8
Indian Airlines	2.1	5.4	9.1	7.9	8.9	7.8	7.9	7.8	7.7
Vayudoot	—	0.0	0.2	0.6	0.5	0.2	— ‡	— ‡	— ‡
Passengers handled at the IAAI (International Airports Authority of India) airports (million)	—	107.4	170.6	177.2	188.2	188.0	209.7	228.9	256.0
Cargo handled at the IAAI airports (thousand tonnes)	—	178.7	331.0	377.3	270.3	391.4	435.4	494.0	561.6

* provisional
† aircraft leased from the Indian Airlines
‡ Vayudoot stands merged with the Indian Airlines

Sources

1. MoF. 1996. Economic Survey, 1995/96. p. S-32. New Delhi: Ministry of Finance.
2 MoF. 1997. Economic Survey, 1996/97. p. S-32. New Delhi: Ministry of Finance.
3. MoF. 1999. Economic Survey, 1998/99. p. S-32. New Delhi: Ministry of Finance.

Table 22

ATF (aviation turbine fuel) offtake (thousand tonnes): 1970/71 to 1997/98

ATF	*Offtake*
1970/71	689
1980/81	1125
1985/86	1453
1990/91	1677
1991/92	1559
1992/93	1565
1993/94	1741
1994/95	1903
1995/96	2082
1996/97	2158
* 1997/98	2118

* provisional

Sources

1. MoPNG. Indian Petroleum and Natural Gas Statistics (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.
2. MoPNG. 1996. Annual Report, 1995/96 New Delhi: Ministry of Petroleum and Natural Gas.
3. MoPNG. 1999. Basic Statistics of Indian Petroleum and Natural Gas. New Delhi: Ministry of Petroleum and Natural Gas.

Table 23

Annual comparative statement of scheduled services of national carriers

	Total traffic					*Traffic on domestic scheduled service*				
	Year			*Variation (%)*		*Year*			*Variation (%)*	
Operations	*1994/95*	*1993/94*	*1992/93*	*1994/95 over 1993/94*	*1993/94 over 1992/93*	*1994/95*	*1993/94*	*1992/93*	*1994/95 over 1993/94*	*1993/94 over 1992/93*
Passenger carried (thousands)	9863.0	9832.0	10212.0	0.3	-3.7	7272.0	7510.0	7888.0	-3.2	-4.8
Passenger-km performed (million)	16479.0	15235.0	15603.0	8.2	-2.4	6545.0	6779.0	7063.0	-3.5	-4.0
Available seat-km (million)	25887.0	24010.0	22880.0	7.8	4.9	10297.0	10821.0	10397.0	-4.8	4.1
Passenger load factor (%)	63.7	63.5	68.2	0.3	-7.0	63.6	62.6	67.9	1.5	-7.8
Freight carried (thousand tonnes)	169.2	143.5	139.1	17.9	3.2	78.6	72.4	0.3	8.6	-5.1
Mail carried (thousand tonnes)	19.5	19.6	18.0	-0.5	8.9	18.2	18.1	16.4	0.6	10.4
Tonne-km performed (million)										
Passenger	1455.6	1335.7	1369.8	9.0	-2.5	543.8	558.6	587.7	-2.6	-5.0
Freight	584.2	421.9	380.6	38.5	10.9	81.1	75.1	81.3	8.0	-7.6
Mail	28.5	29.7	26.5	-4.0	12.1	20.1	20.1	18.5	—	8.6
Total	2068.3	1787.3	1776.9	15.7	0.6	645.0	653.8	687.5	-1.3	-4.9
Total available tonne-km (million)	**3339.2**	**2964.3**	**2853.5**	12.6	3.9	**1122.1**	**1144.7**	**1101.8**	-2.0	3.9
Weight load factor (%)	61.9	60.3	62.3	2.7	-3.2	57.5	57.1	62.4	0.6	-8.5

Source

DGCA. 1995. India Air Transport Statistics 1994/95. New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

Table 24

Total domestic passenger traffic carried by the Indian Airlines, the Air India, and the Vayudoot (million) 1985/86 to 1994/95

Year	Indian Airlines	Air India	Vayudoot	**Total**
1985/86	8.60	0.20	0.20	**9.00**
1986/87	9.40	0.20	0.30	**9.90**
1987/88	9.90	0.30	0.40	**10.60**
1988/89	9.54	0.30	0.45	**10.29**
1989/90	9.39	0.38	0.14	**9.91**
1990/91	7.47	0.39	0.44	**8.30**
1991/92	8.31	0.30	0.30	**8.91**
1992/93	7.27	0.31	0.21	**7.79**
1993/94	7.23	0.28	—	**7.51** *
1994/95	6.90	0.37	—	**7.27** *

* exclusive of Vayudoot figures

Source
DGCA 1995 India Air Transport Statistics 1994/95. New Delhi Directorate of Regulations and Information, Director General of Civil Aviation.

Table 25

Total domestic and operating statistics of the Indian Airlines, the Air India, and the Vayudoot

Year	Aircraft flown		Passengers		Available seat-km (thousand)	Pax load factor (%)	Cargo carried (tonne)			Tonne km performed (thousand)				Available tonne-km (thousand)	Weight load factor (%)
	Hours	km (thousand)	Carried	km performed (thousand)			Freight	Mail	Total	Pax	Freight	Mail	Total		
1991/92	135839	67763	8919200	7930803	11653126	68.1	86137	15687	101824	654243	92484	17240	763967	1244571	61.4
1992/93	122574	60974	7887877	7146702	10397137	68.7	76346	16436	92762	587690	81261	18531	687482	1101836	62.4
1993/94*	105256	58190	7510498	6778617	10820752	62.6	72406	18185	90591	558696	76183	20142	654021	1144713	57.1
1994/95*	101855	57777	7271833	6544989	10297469	63.6	78654	18183	96837	543842	81111	20084	645037	1122093	57.5

* data exclude Vayudoot figures

Source
DGCA 1995 India Air Transport Statistics 1994/95 New Delhi Directorate of Regulations and Information, Director General of Civil Aviation.

Table 26

Total traffic and operating statistics of all scheduled services of the Indian Airlines: 1985 to 1997/98

	Aircraft flown		Passengers			Pax	Cargo carried (tonne)			Tonne km performed (thousand)					
Year	Hours	km (thousand)	Carried	km performed (thousand)	Available seat-km (thousand)	load factor (%)	Freight	Mail	Total	Pax	Freight	Mail	Total	Available tonne-km (thousand)	Weight load factor (%)
1985	124929	62351	9081600	7141886	9619779	74.2	104497	18385	122882	582215	104966	18413	705594	1012183	69.7
1986	132898	67312	9695349	7817061	10550259	74.1	97500	17853	115353	643695	98513	17742	759950	1088896	69.8
1987/88	135435	70425	10454850	8645226	11049886	78.2	109585	16491	126076	709813	112149	18035	839997	1145141	73.4
1988/89	123248	67516	10082619	8659433	10742812	80.6	111442	16877	128319	706144	113793	18494	838431	1095882	76.5
1989/90	116832	65382	9830138	8611625	11230686	76.7	101308	16433	117741	702864	103869	17184	82397	1130472	72.9
1990/91	94690	51985	7854444	7188215	9106368	78.9	85851	15175	101026	589412	91937	16285	697634	923302	75.6
1991/92	114750	61720	8871801	7979314	10866776	73.4	82486	15889	98375	654202	88469	16982	759653	1086886	69.9
1992/93	103073	54956	7806764	7187868	9768235	73.6	72374	16605	88979	588699	77621	17913	684233	965707	70.9
1993/94	107340	59521	7884376	7237448	10595678	68.3	72186	18326	90512	597953	76466	20139	694558	1055762	65.8
1994/95	105544	59643	7611191	6981609	10019710	69.7	76705	18297	95002	582791	80904	20146	683841	1022264	66.9
1995/96	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1996/97	—	—	—	—	—	—	—	—	—	—	—	—	—	1075238	64.9
1997/98	—	—	—	—	—	—	—	—	—	—	—	—	—	1094132	64.1

Sources

1. DGCA 1995. India Air Transport Statistics 1994/95. New Delhi Directorate of Regulations and Information, Director General of Civil Aviation.

2 MoCA. 1999. Annual Report, 1998/99 New Delhi Ministry of Civil Aviation

Table 27

Total traffic and operating statistics of all scheduled services of the Air India: 1985 to 1997/98

	Aircraft flown		Passengers			Pax	Cargo carried (tonne)			Tonne-km performed (thousand)					
Year	Hours	km (thousand)	Carried	km performed (thousand)	Available seat km (thousand)	load factor (%)	Freight	Mail	Total	Pax	Freight	Mail	Total	Available tonne-km (thousand)	Weight load factor (%)
1985	61795	42556	1742295	7620417	11071839	68.8	73453	3074	76527	696288	408998	14734	1120020	1805949	62.0
1986	61764	42077	1789870	7608528	11062882	68.8	79050	1967	81017	709179	439902	9855	1158936	1866169	62.1
1987/88	73932	50523	2119089	9007649	12986744	69.4	97618	1847	99465	835779	505771	9379	1350929	2169152	62.3
1988/89	72543	50019	2110200	8948507	13473795	66.4	96700	1357	98057	828602	531841	7924	1368367	2163562	63.2
1989/90	74003	52053	2238335	9268568	14460469	64.1	106495	1456	107951	855997	574049	8952	1438998	2259504	63.7
1990/91	67548	47838	2046847	8492761	12736721	66.7	95212	1661	96873	783593	548627	10454	1342674	2152423	62.4
1991/92	68941	46963	1983492	8078244	13129624	61.5	75621	1915	77536	747144	380612	12787	1140543	1946737	58.8
1992/93	66990	46518	2178706	8415969	12991472	64.8	66845	1196	68041	774507	302944	8622	1086073	1876969	57.9
1993/94	68880	47909	1947374	7997614	13414297	59.6	71373	1420	72793	737822	345574	9652	1093048	1908608	57.3
1994/95	78943	55554	2251437	9497450	15867729	59.9	92509	1169	93678	872883	503281	8392	1384556	2316915	59.8
1995/96	—	—	—	—	—	—	—	—	—	—	—	—	—	1045800	—
1996/97	271200	—	2910000	11588600	17652000	65.7	—	—	—	—	—	—	—	2452100	60.5
1997/98	270500	—	2930000	11422400	16933300	67.5	—	—	—	—	—	—	—	2293700	63.4

Sources

1. DGCA. 1995. India Air Transport Statistics 1994/95 New Delhi Directorate of Regulations and Information, Director General of Civil Aviation.

2. MoCA.1999 Annual Report, 1998/99 New Delhi Ministry of Civil Aviation

Table 28

Road length (km) by category: 1971 to 1996

Highways	*1971*	*1976*	*1981*	*1985*	*1986*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996* *
Highways	711966	943616	1176790	1347998	1381128	1801684	1619804	1697291	1718172	1743183	1965461
Maintained by the PWD (Public Works Department)	357436	458846	547925	620921	633418	670396	683316	659628	667265	679393	933654
National highways	23838	29132	31671	31852	32088	33650	33666	33916	34249	34282	34508
State highways	56765	89215	94359	99262	100461	127311	128622	129876	132401	134065	135187
Other/PWD roads	276833	340499	421895	489807	500869	509435	521028	495836	500615	511046	763959
Panchayat roads	354530	484770	628865	727077	747710	931288	936288	1037663	1048907	1063790	1021807
Urban roads	72120	97490	123120	135299	138647	186799	189352	195150	202013	202671	210680
Project roads	130893	163745	185511	203651	206276	209737	212485	222057	224606	225481	237513
Total	**914979**	**1204851**	**1485421**	**1686948**	**1726051**	**2327382** †	**2462289** †	**2678843** †	**2955231** †	**3067411** †	**3319644**

* estimate

† including road lengths constructed under Jawahar Rozgar Yojana

Sources

1. MoST 1995. Basic Road Statistics of India, 1989/90 to 1991/92. p 13 New Delhi Transport Research Wing, Ministry of Surface Transport. 251 pp.
2. MoST 1999 Motor Transport Statistics of India – 1997 p 10 New Delhi Transport Research Wing, Ministry of Surface Transport.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 29

Total and surfaced length (km) of national highways (as on 31 March): 1971 to 1996

State/union territory	1971		1981		1991		1994		1996	
	Total	*Surfaced*	*Total*	*Surfaced*	*Total*	*Surfaced*	*Total*	*Surfaced*	*Total*	*Surfaced*
State										
Andhra Pradesh	2233	2233	2352	2352	2587	2556	2949	2918	2949	2918
Arunachal Pradesh	—	—	330	330	368	271	368	271	368	271
Assam	1186	1176	2198	2149	2227	2227	3354	2253	2254	2253
Bihar	1914	1695	2188	2138	2118	2118	2118	2118	2118	2118
Goa	—	—	223	208	225	225	225	225	225	225
Gujarat	1056	1056	1424	1424	1572	1572	1570	1570	1570	1570
Haryana	662	662	655	655	655	655	656	656	656	656
Himachal Pradesh	229	229	589	589	722	718	728	723	732	727
Jammu and Kashmir	504	504	593	593	648	648	648	648	648	648
Karnataka	1269	1185	1968	1968	1997	1997	1997	1997	1997	1997
Kerala	451	451	837	837	817 ‡	817 ‡	1011	1011	1011	1011
Madhya Pradesh	2675	2509	2688	2678	2976	2976	2976	2976	2976	2976
Maharashtra	2366	2366	2945	2945	2949	2901	2953	2905	2958	2910
Manipur	209	209	431	431	434	434	434 ‡	434 ‡	438	438
Meghalaya	161	161	461	461	462	462	454	454	464	464
Mizoram	—	—	240	240	571	571	566	566	566	566
Nagaland	110	110	113	113	113	113	113	113	113	113
Orissa	1358	1275	1631	1604	1624 ‡	1553	1624	1624	1625	1590
Punjab	528	528	977	977	968 ‡	968 ‡	988	988	988	988
Rajasthan	1256	1256	2521	2521	2840	2840	2846	2846	2846	2846
Sikkim	62	62	62	62	41	41	53	53	53	53
Tamil Nadu	1653	1653	1867	1867	2002	2002	2002	2002	2002	2002
Tripura	—	—	198	198	195	195	198	198	198	198
Uttar Pradesh	2455	2455	2474	2474	2754	2754	2733	2733	2862	2862
West Bengal	1422	1422	1605	1605	1651	1651	1651	1651	1651	1651
Union territory										
Andaman and Nicobar Islands	—	—	—	—	—	—	—	—	—	—
Chandigarh	—	—	14	14	34	34	34	34	34	34
Dadra and Nagar Haveli	—	—	—	—	—	—	—	—	—	—
Delhi	79	79	87	87	75	75	75	75	75	75
Lakshadweep	—	—	—	—	—	—	—	—	—	—
Pondicherry	—	—	—	—	25	25	25	25	31	31
All-India	**23838**	**23276**	**31671**	**31520**	**33650**	**33399**	**33249**	**34033**	**34508**	**34291**

* Includes data for Daman and Diu also

‡ for 1989/90

Source

MoST. 1993 Pocket Book on Transport Statistics in India, 1993. pp 27–33 New Delhi: Transport Research Division, Ministry of Surface Transport. 296 pp.

MoST. 1998. Basic Road Statistics of India 1995/96 pp 25–26. Transport Research Division, Ministry of Surface Transport.

Table 30

Road length in relation to area and population in states and union territories: 31 March 1996

State/union territory	*Total road length (km)*	*Area (km²)*	*Population: 1991 census (million)*	*Road length (km)* Per hundred km² of area	*Road length (km)* Per million of population
State					
Andhra Pradesh	172669	275068	66.4	62.8	2600
Arunachal Pradesh	10240	83743	0.9	12.2	11378
Assam	68079	78438	22.3	86.8	3053
Bihar	85565	173877	86.3	49.2	991
Goa	7457	3814	1.2	195.5	6214
Gujarat	133850	196024	41.2	68.3	3249
Haryana	27907	44212	16.3	63.1	1712
Himachal Pradesh	29610	55673	5.1	53.2	5806
Jammu and Kashmir	13042	222236	7.7	5.9	1694
Kamataka	142754	191791	44.8	74.4	3186
Kerala	141856	38863	29.0	365.0	4892
Madhya Pradesh	198936	443446	66.1	44.9	3010
Maharashtra	359262	307690	78.8	116.8	4559
Manipur	10760	22327	1.8	48.2	5978
Meghalaya	8391	22429	1.8	37.4	4662
Mizoram	6910	21081	0.7	32.8	9871
Nagaland	13732	16579	1.2	82.8	1143
Orissa	210238	155707	31 5	135.0	6674
Punjab	58151	50362	20.2	115.5	2879
Rajasthan	134632	342239	43.9	39.3	3067
Sikkim	1834	7096	0.4	25.8	4585
Tamil Nadu	205706	130058	55.6	158.2	3700
Tripura	14726	10486	2.7	140.4	5454
Uttar Pradesh	237358	294411	139.0	80.6	1708
West Bengal	77579	88752	68.0	87.4	1141
Union territory					
Andaman and Nicobar Islands	1224	8249	0.3	14.8	4080
Chandigarh	1723	114	0.6	1511.4	2872
Dadra and Nagar Haveli	518	491	0.1	105.5	5180
Delhi	26582	1483	9.4	1792.4	2828
Daman and Diu	—	3814	0.1	—	—
Lakshadweep	—	32	0.1	—	—
Pondicherry	2343	495	0.8	473.3	2929
All-India	**2403634**	**3291080**	**844.3**	73.0	2847

' excluding Jawahar Rozgar Yojna roads

Source

MoST. 1998. Basic Road Statistics of India, 1995/96. p.17 New Delhi: Ministry of Surface Transport.

Table 31

Status of BOT (build-operate-transfer) projects awarded as on 25 November 1998

Name of the project	National Highway number	State	Length/ number	Cost (million rupees)	Concession period	Construction period	Date of signing	Date of completion	Type of vehicle tolled	Fee rates (rupees/trip)
Thane–Biwandi Bypass	3 and 4	Maharashtra	24 km	1030	18 years 6 months	36 months	09/12/95	31/12/2001	Cars/vans	10
									trucks	30
• Chaltan ROB (road over bridge)	8	Gujarat	14 Lane ROB	100	41 months 22 days	18 months	19/09/96	15/7/1998	Cars/vans	5
									trucks	15
									buses	15
• Udaipur Bypass	8	Rajasthan	11 km	240	11 years 8 months	18 months	July 1996	22/04/1998	Cars/vans	6
									buses	15
Construction of six bridges	5	Andhra Pradesh	6 nos	50	19 years 60 days	4 years	09/04/97	08/06/2001	Cars/jeeps	5
									buses	15
									trucks	
									autorikshaw	2
Coimbatore Bypass	47	Tamil Nadu	33 km	900	32 years	24 months	03/10/97	03/12/99	Cars/jeeps	19
									LCVs	28
									buses	56
Durg Bypass	6	Madhya Pradesh	18 4 km	680	32 years 6 months	30 months	05/11/97	05/05/2000	Cars/jeeps	
									LCVs	
									buses	
									trucks	50
									MAVs	
Narmada Bridge	8	Gujarat	6	1130	15 years	3 years	21/11/1997	21/12/2000	Trucks/bus	33
									LCV	
									cars	
Nardhana ROB	3	Maharashtra	13 km	340	15 years 10 months	3 years	25/11/1997	25/11/2000	trucks	30
									bus	25
									trailer	80
									car	8
Patalganga Bridge	17	Maharashtra	1 ROB	430	17 years 9 months	2 years 9 months	29/11/1997	29/8/2001	Trucks	50
									trailer	
									trucks/bus	30
Hubli–Dharwar Bypass	4	Karnataka	30.35 km	680	26 years	3 years 6 months	05/02/98	15/11/2001	Cars/jeep	10
									van	
									bus	35
									truck	43
									LCV	25
									MAVs	40
Nellore Bypass	5	Andhra Pradesh	18 km	730	31 years 6 months	30 months	17/02/1998	17/02/2001	Cars/jeep	24
									van	
									bus	36
									truck	48
									LCV	
									MAVs	60
Koratalaiyar Bridge	5	Tamil Nadu	–	300	9 years 11 months 16 days	24 months	28/10/1998	Oct. 2000	Cars/jeep	8
									van	
									LCV	15
									truck/bus	30
									MAV/MCM	40
									EME	
Khambatki Ghat tunnel and road	4	Maharashtra	8	378	9 years 9 months	24 months	16/11/1998	Nov 2000	Car/jeep	10
									truck/bus	30
									trailer	50
Nasirabad ROB	6	Maharashtra	30 m	104.5	10 years 11 months	12 months	16/11/1998	Nov. 1999	Car/jeep	05/08/10
									bus	15/20/25
									truck	20/25/30
									trailer	30/35/40
Wainganga Bridge	6	Maharashtra	530 m	326	18 years 9 months	30 years	16/11/1998	May 2001	Car/jeep	10
									bus	50
									truck	50
									trailer	80
Mahi Bridge	8	Gujarat	–	420	7 years 8 months	18 months	16/11/1998	July 2000	Car/jeep	10
									van	
									LCV	20
									truck/bus	35
									MAV/MCM	75
									roller	
ROB Kishangarh bypass	8	Rajasthan	1	166.6	51 months	15 months	27/11/1998	24/4/2000	Car/jeep	20
									van	
									LCV	30
									truck/bus	40
									MAV/MCM	60
									roller	

• completed and open to traffic

Source
MoF 1999 Economic Survey 1998/99 New Delhi Ministry of Finance

Table 32

Private sector/captive port projects approved so far (position as on 6 November 1998)

Scheme	Port	Capacity (million tonnes)	Project cost (million rupees)	Name of Party
Container terminal	Jawaharlal Nehru Port	6.0	8000	P&O The project is under construction
Liquid cargo berth	Jawaharlal Nehru Port	4.5	2000	Bharat Petroleum Corporation Ltd & Indian Oil Corporation Ltd, agreement is expected to be executed in a fortnight's time
Fifth oil jetty	Kandla	2.0	210	Indian farmers fertilizers cooperation Limited. Completed
Oil jetty at Vadnar	Kandla	15.0	14000	Essar Oil Ltd. Terms of agreement have been approved on 7.8.98
Off-shore stockyard and berth	Mormugao	5.0	3000	Mormugao Martina
Initially constructing a virtual jetty and then converting into permanent jetty	Kandla	2.0	900	Indian Oil Corporation Ltd Virtual jetty completed
Container terminal	Tuticorin	3.6	1000	PSA Agreement signed on 15.7.98
Initially constructing a virtual jetty and then converting into permanent jetty	Kandla	2.0	900	Hindustan Petroleum Corporation Ltd virtual jetty completed
Construction of petroleum, oil, and lubricants jetty	Kandla	2.0	750	Bharat Petroleum Corporation Ltd

Source

MoST. 1999. Annual Report 1998/99. New Delhi: Ministry of Surface Transport

Table 33

Public sector plan investment (million rupees) in the transport sector

Sector	*Fifth Plan (1974–78)*	*Sixth Plan (1980–85)*	*Seventh Plan (1985–90)*	*Annual Plans (1990–92)*	*Eighth Plan (1992–97)*	*1992/93 actual*	*1993/94 actual*	*1994/95 actual*	*1995/96 revised*	*1996/97 budget estimate*
Railways	20630	65870	165490	102177	272020	81620	59010	54720	75000	81300
Roads and bridges	17010	38070	63348	37790	132100	22974	25882	31862	17723	46658
Road transport	5030	12760	21510	11640	38495	5507	6610	6576	8637	9419
Ports and lighthouses	4970	7250	15206	8789	35920	3223	7337	4077	8357	7142
Shipping	4690	4680	7190	10068	36689	3869	8617	8695	7491	20066
Inland water transport	160	630	1876	1036	3476	193	251	360	394	549
Civil aviation	2940	9570	19480	7645	41059	8822	11465	14436	21001	41858
Others	—	—	470	1196	1660	419	597	240	704	1521
Total transport	**55430**	**138830**	**294570**	**180341**	**561419**	106627	**119768**	**120966**	**141307**	**208513**
Total Plan	**394262**	**1092917**	**1792770**	**1370336**	**4341000**	**728524**	**880807**	**981673**	**1199543**	**1461067**

includes provision for continuing corrective works on the Bhagirath–Hoogly rivers, the Farakka Barrage, state's share in the railway projects, urban transport, road safety, etc.

Note
The individual totals may not add up to grand total due to rounding off.

Sources
1. GoI. Annual Plans (various issues). New Delhi: Planning Commission, Government of India.
2. GoI. 1992. Eighth Five Year Plan, 1992–97. Volume II. p. 257. New Delhi: Planning Commission, Government of India. 480 pp.

For more details, please see TEDDY ONLINE+ [Section: Transport (general)]

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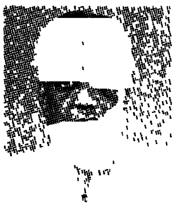
PHILIPS ECOTONE–The Lamp of the Future



S. Venkataramani
Vice-President
(Business Group Lamps)

We, at Philips Lighting, have always tried to make things better for our consumers and for society as a whole by introducing to the world the benefits of "Good Lighting". It is in this endeavour that we introduced the energy saving Ecotone Compact Fluorescent Lamps nearly 2 years ago in India. Available in wattages that surprise most people (from 9 watts to 23 watts) these lamps use 80% less electricity than ordinary bulbs and last approximately 5 years. And as they consume less amount of watts than normal bulbs for the same light output, they are cool on the environment. Widely accepted the world over as a cost saving alternative to the ordinary bulb, the Compact Fluorescent Lamp is gaining ground in India. The Ecotone range is the latest in the retrofit variety of the Compact Fluorescent Lamp and has much to offer. New developments are taking place on regular basis and more variants in this range are going to be introduced. Technological advances in our research facilities across the world have enabled us to consistently provide consumers with more efficient lamps. We look forward to continued innovations that make our consumer's lives a little brighter. We believe that the Ecotone is most definitely the lamp of the future.

As the Ecotone is a new concept in lighting technology, many people are unclear as to the how's and why's of this product. We receive numerous letters and emails from customers asking us for more information on this product. A selection of some of the frequently asked questions are given below :

Ecotone bulbs are available in wattages of 9W to 23W. Does this mean they give dim light?

On the contrary, it is this very feature that enables one to save electricity. A 20W Ecotone gives equivalent light output of a 100W ordinary bulb. Therefore, instead of consuming 100W one just consumes 20W (i.e. 1/5th the wattage.)

**COMPARISION OF LIGHT OUTPUT
BETWEEN ORDINARY BULBS AND
ECOTONE OF COMPARATIVE WATTAGE**

Ordinary	40W	60W	75W	100W	125W
Ecotone	9W	11W	15W	20W	23W

Because this is like a tubelight, will it have a start-up problem during low voltage ?

The Ecotone is a Compact Fluorescent Lamp. It combines all the positive features of an ordinary bulb and a tubelight. For example, a Philips Ecotone works efficiently within the range of 170V to 250V. It is ideal for Indian conditions characterized by low voltage and severe voltage fluctuations. Moreover, it is flicker-free and starts in an instant, because of its electronic circuitry.

ADVT.

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Do we need to get an electrician to get the Ecotone fitted ?

Fit the Ecotone in your normal bulb holder just as you would a normal bulb. An additional accesssory like a ballast or starter is not required.

Is there only one Ecotone bulb ?

We have a range of Ecotones to offer you. Each is available in a variety of wattages. Ecotones can, as mentioned earlier, give white light or yellow light. They are available in different shapes and sizes, from the pear shaped Ambiance to the globe shaped Decor. Ecotones are available to match your lighting and aesthetic needs.

Aren't these bulbs overpriced ?

The Ecotones are indeed much costlier than ordinary bulbs. But one must keep in mind that the Ecotone range of lamps lasts 6 times longer than ordinary bulbs in addition to their energy saving capability. These bulbs actually pay one back more than their cost during this time through its efficient use of electricity. Moreover, one also contributes to a greater social benefit of energy saving.

Where can I use an Ecotone ?

Wherever you are using an ordinary bulb. You can use it in the same bulb holder. Just make sure that the holder is of good quality. One can replace all ordinary bulb points in a home with Ecotone. Its usage is particularly ideal in areas where prolonged period of lighting is required, as in hotels (especially foyers, corridors and rooms) in shops, restaurants and hospitals. Significant savings can be realised by switching over from conventional light sources. Find out how much you can save if you switch to Philips Ecotone of comparitive wattage.

Replace a 100W GLS with a 20W Ecotone and save Rs. 438 per year (assuming 6 burning hours a day and electricity cost @Rs. 2.50 per unit)

The author is the Vice President of Business Group Lamps, Philips India Ltd. For further queries write to the author at :

s.venkataramani@philips.com or Philips India Ltd.,
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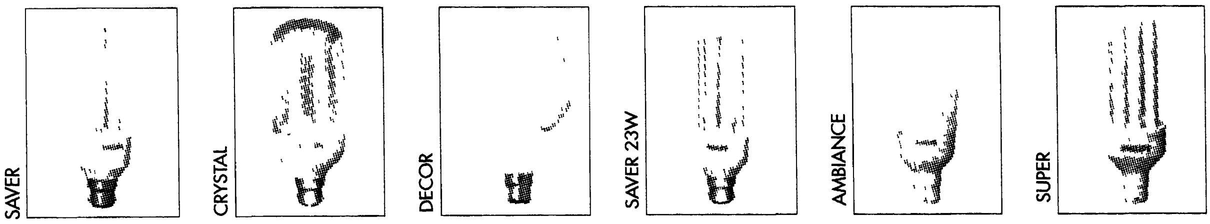
Bring down your Lighting Bill by 80%



Switch to Philips Ecotone

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Once, the spice trade revolutionised the peninsular economy.

And now, the Cochin International Airport at Nedumbassery - the most modern and well-equipped airport in India - is all set to boost the exports and the tourism industry, and take the region to new heights of prosperity.

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Beyond financing such infrastructure projects crucial to development, Hudco also evaluates their design, planning and engineering soundness, and their economic viability.

Hudco also assists in designing and building homes, by promoting cost-effective and innovative technologies.

Hudco's role is large, and expanding. Today, it contributes to capacity building by forging partnerships between public and private bodies - from municipal corporations to NGOs - to enhance the quality of life in towns and cities.

And the Hudco Niwas Individual Housing Loan Scheme is an endeavour to ensure homes for the common man.

Hudco's expertise and activities are changing the face of more than 1700 towns and thousands of villages.* Efforts that are ensuring that development and infrastructures reach the very grass-roots, and help build a stronger foundation for the future.

**Hudco has funded over Rs 23,241 crores for projects worth over Rs 38,756 crores, towards: 86 lac homes, 48 lac sanitation units, 5.2 lac residential plots, 626 building centres and 719 urban infrastructure projects costing Rs 13,988 crores of which Hudco's contribution is Rs 7,552 crores.*

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Ogilvy & Mather 492

Domestic sector

Introduction

Energy consumption in the domestic sector is influenced by economic growth, growth in the number of households, and the changes in lifestyles. The factors that have a major impact on the amount of energy consumed by households and the fuels used include (1) the income levels; (2) the size of settlement, family, and city; (3) population density; (4) the price of fuels; (5) the availability of, and accessibility to, modern fuels; and (6) the efficiency of end-use equipment.

At the all-India level, the number of households in India has increased from 97 million to 152 million during 1971–91, registering a growth of 26.3% a year during 1971–81 and 24% a year during 1981–91. While the increase in the number of rural households during 1971–91 was of the order of 34 million (from 78 million to 111.6 million), it was 21 million (from 19.1 million to 40.4 million) for urban households during the same period.

The GDS (gross domestic saving) in the household sector is one of the factors that determines the lifestyle and consumption behaviour of people. It is observed that during 1980–95, the GDS in the household sector increased from about 16% to 22% of the GDP (gross domestic product).

Changes in lifestyle and standard of living

Along with the higher proportion of financial savings that can be mobilized, the statistics on average MPCE (monthly per capita expenditure) released by the NSSO (National Sample Survey Organization) indicates rising trends in the disposable income of households. In the absence of other published data on household income, the household expenditure is considered as a proxy to understand the economic well-being of the people. The MPCE is adjusted by using the CPI (consumer price index) for agricultural labourers (for rural areas with base year 1960/61) and the CPI for industrial workers (for urban areas with base year 1982). The monthly values are multiplied by 12 to estimate the annual per capita consumption adjusted for the prices prevailing in each year. In the period spanning 16 years (from 1977/78 to 1993/94), the increase is observed to be 2.55–3.03 rupees in rural areas and 17.49–21.30 rupees in urban areas.

There is a major shift in the household consumption expenditure, which is also indicative of the lifestyle changes. The monthly consumer expenditure on fuel and lighting has registered an increase as revealed by the various quinquennial surveys of the NSSO. Table I reveals that there has been an increase in both rural and urban areas. The household expenditure on fuel and light has gone up from 5.6% in 1977/78 to 7.3% in rural areas and from 5.7% to 7.1% in urban areas. The percentage increase in rural areas is higher in almost all cases than the corresponding figures for urban areas, except in 1977/78.

Access to electricity, coupled with a higher disposable income, has contributed to a change in lifestyles and consumption behaviour of households. There has been a significant growth in the number of households with access to electricity (from 26.2% to 42.4% during 1981–91). In 1991, 76% of the

Table I Monthly consumer expenditure on fuel and light (%)

Year	*Rural*	*Urban*
1977/78	5.56	5.71
1983	7.08	6.82
1987/88	7.44	6.69
1993/94	7.35	6.60

Source NSSO (1996)

urban households and 31% of the rural households had reported electrification.

The NCAER (National Council of Applied Economic Research) has been conducting MISH (market information surveys of households) every year since 1985. MISH provides useful information on the purchase of selected manufactured consumer goods by the households. There is an increasing trend in the purchase of electrical appliances such as televisions, refrigerators, washing machines, ceiling fans, electric irons, and geysers (Tables 3 and 4). The increase in refrigerators and geysers is particularly significant: from 0.56 million in 1985/86 to 1.99 million in 1995/96 for refrigerators and from 76 000 to 321 000 in the case of geysers between 1989/90 and 1995/96. There has also been an increase in purchase of table fans from 1.7 million in 1985/86 to 3.19 million in 1995/96.

The rapid pace of urbanization and diverse urban growth patterns involve many basic structural changes in the economy, which have major implications for energy use. Urbanization brings with it changes in the way resources are collected, distributed, and used. In rural areas, people are directly involved in these activities; in cities, there is greater dependence on supply networks to meet these needs. As cities grow, the pressure on these networks increases.

The rising per capita income associated with urbanization increases demands for both end-use energy and energy-intensive products and services. Increases in household income lead to shifts upwards along the energy ladder as shown in Figure 1. This implies that with increasing incomes, people shift to more efficient, cleaner, and more expensive but convenient fuels. The growth in disposable incomes in urban areas leads to increased energy demand, particularly for fuels such as electricity and LPG (liquefied petroleum gas).

Even in urban areas, poor households are heavily dependent on biofuels. However, unlike the rural areas, where most of the fuel required is gathered, the poor in urban areas have to buy biofuels. These fuels are burnt in devices that are less efficient and the cost per unit of 'useful energy' may be higher than that obtained from modern fuels. The prices of energy products have increased faster compared to other commodities. This is especially hard on the poor as energy forms the bulk of their household expenditure.

There is evidence of an energy transition in both rural and urban areas for the purpose of cooking although it is more pronounced in urban areas. Tables 6 and 7 present the percentage distribution of households according to the primary source of energy used by households for cooking at the national level for each MPCE class in both rural and urban sectors. At the higher MPCE level, households use gas, and at the lower level, households use 'firewood and chips' as the primary source of energy in both rural and urban areas.

Figure 2 plots the MPCE classes against the percentage of households using the primary source of energy for cooking. It is worth noting that 10%–12% of households in all the MPCE classes in the rural sector use dungcakes as the primary source

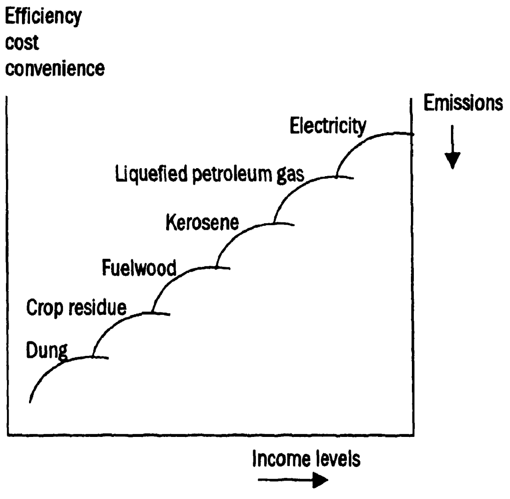

Figure 1 Energy ladder

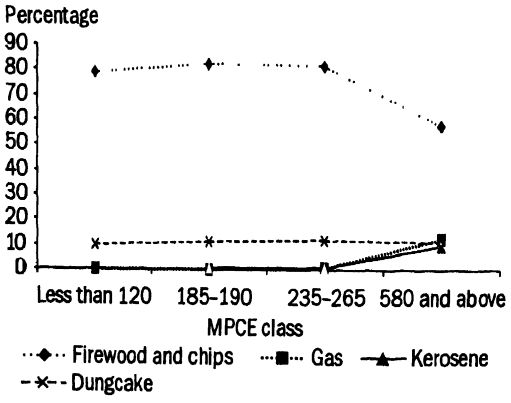

Figure 2 Rural households using primary fuel for cooking across income classes

Source NSSO (1997)

of energy for cooking. Seventy-eight per cent of the rural households depend on firewood and chips. Interestingly, around 30% of the urban households are also dependent on it for cooking.

Most of the people in rural areas and small towns procured fuels free of cost in the past, due to the dominance of traditional forms in the fuel mix. With increasing scarcity of these traditional fuels, it is no longer possible to collect adequate quantities of fuelwood. As traditional fuelwood resources are getting depleted, people are forced to burn inferior-quality fuels such as twigs, crop residues, and animal dung. The heavy dependence on traditional fuels has led to several health and ecological problems as well.

The household income emerges as the major determinant of the urban energy scenario. Figure 3 shows that the use of firewood for cooking decreased after attaining its peak value in the MPCE class ranging from 190 rupees to 230 rupees. The trend is similar in the case of kerosene, although its peak value is attained in the higher MPCE class (410–490 rupees). In contrast, the use of gas experienced an upward trend with increase in MPCE classes. However, the same cannot be said for rural households as they have a more limited set of fuel options to choose from.

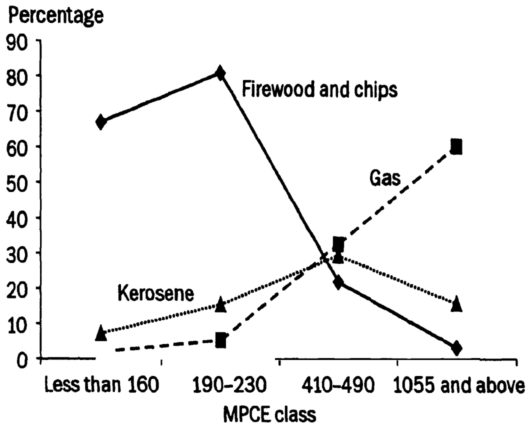

Figure 3 Urban households using primary fuel for cooking across income classes
Source NSSO (1997)

Energy consumption: data sources

A basic problem in most developing countries is the lack of up-to-date information on non-commercial energy sources. Information on household energy consumption is available only from sample surveys. However, these surveys suffer from a major drawback that the actual energy-use is only an estimation using some standard norms while conducting the survey. Over the past three decades, several attempts have been made at the governmental level to estimate the aggregate energy demand in the urban and rural domestic sectors. The various studies carried out in estimating energy demand have been listed below.

1. The Energy Survey of India Committee report, published in 1965, used the NCAER survey data (obtained in 1962) and aggregated the fuel mix at the national level based on the data of around 9000 rural households.
2. The Working Group on Energy Policy set up by the Government of India in 1977, which published its report in 1979, quoted extensively the results of the 18th and 28th rounds of the NSS (National Sample Survey) to project the aggregate energy demand.
3. The ABE (Advisory Board on Energy), which published its report in 1985, used the NCAER 1978/79 survey results to project the energy demand. Table 13 shows the changes in energy consumption in the domestic sector for the period 1970/71 to 1982/83.
4. The EDSG (Energy Demand Screening Group) set up by Planning Commission, which published its report in 1986, used data of various energy surveys and initialized the energy sector model for inter-sectoral models. Table 23 gives the annual demand for different fuels for the period 1989/90 to 2004/05.
5. In 1991, the Planning Commission published another report on the inter-sectoral energy demand titled the 'Sectoral Energy Demand for India'. This report used the published information on energy demand and using the MEDEE-S (Modeled evolution de la demande energie) method, projected energy demand for 1999/2000 and 2004/05 (Table 23).
6. In 1998, the Planning Commission made energy demand projections in the report titled *Sectoral Energy Demand in the Ninth Plan and the Perspective Period up to 2011/12.* The assumptions for cooking and energy demand projections for cooking and lighting are given in Tables 20 and 21.
7. The NCAER conducted energy surveys in 1978/79 and in 1992/93. While the former

covered both the urban and rural areas, the latter was confined only to villages. For the first time, in 1991, the Census of India collected information on the type of fuels used (in percentage share for both commercial and non-commercial) at the household level for cooking. In addition to this, information was also collected from households having electricity.

8. In 1992, TERI prepared a comprehensive rural energy database (REDB), based on the rural energy surveys conducted between 1985 and 1992 by different agencies. The REDB is updated regularly taking inputs from energy surveys conducted by TERI and other agencies. Table 14 and 16 give the annual consumption and daily per capita consumption of bio-fuels in the rural domestic sector. TERI also carried out surveys on the urban energy-use patterns in five regions of India, namely, north, south, east, west, and central. Table 22 gives the projected annual consumption of fuel by urban households across various income groups.
9. Other significant data sources on the rural domestic sector are the IREP (Integrated Rural Energy Programme) surveys conducted by various state departments. The results of these surveys were published in the Eighth Five-Year Plan.

There seems to be discrepancies in the data provided by the IREP, the REDB, and the NCAER (Figure 4). The REDB estimates for firewood are higher largely due to high consumption in Andhra Pradesh, Madhya Pradesh, Orissa, Tamil Nadu, and West Bengal. The IREP estimates for firewood, on the other hand, are substantially higher for Gujarat, Kerala, and Uttar Pradesh. Similarly, the NCAER estimates on the use of dungcakes in Bihar and Madhya Pradesh are substantially higher than those provided by the IREP or the REDB.

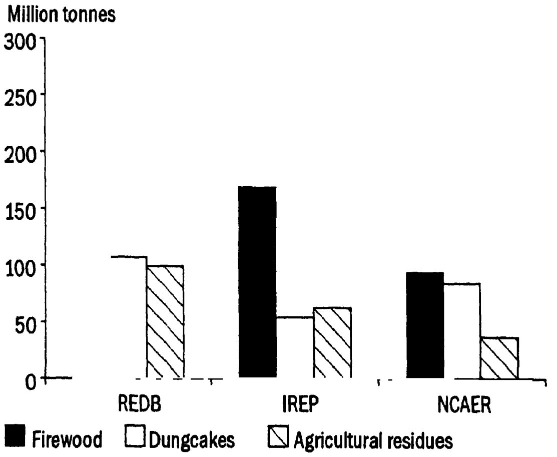

Figure 4 Total annual non-commercial energy use
Source Ravindranath and Hall (1995)

Energy consumption in the domestic sector

The domestic sector accounts for 40%–50% of the total energy consumption in the country. Firewood is the most preferred form of biomass energy, followed by dungcakes and agricultural residues. However, the use of traditional fuels in the national energy mix is decreasing as more efficient commercial fuels are increasingly substituting these. The consumption of total commercial energy by households, largely urban, increased at the rate of 8.1% a year over the period 1981–91. The daily energy consumption of poor households is between 1256 kJ and 2093 kJ of useful energy per capita. This is much lower than the minimum requirement of 2847 kJ worked out by the ABE.

The household sector showed a steady shift from non-commercial to commercial energy sources between 1984/85 and 1991/92. Among the commercial fuels, petroleum products in the form of kerosene and LPG account for nearly two-thirds of the consumption of commercial fuels, the share of coal being one-fourth and that of electricity one-tenth.

The consumption of commercial energy sources has increased considerably over the past two decades. In particular, between 1970/71 and 1994/95, the annual consumption of electricity per household went up from 7 kWh to 53 kWh; of motor spirit from 2.9 kg to 4.6 kg; of kerosene from 6.6 to 9.9 kg; and of cooking gas from 0.33 kg to 3.8 kg (Table II).

There is a marked disparity in the level of energy consumed in the rural and urban areas. The per capita energy consumption in urban areas has increased by almost 50% in all the states. This rural–urban disparity exists in the type of fuels and cooking devices used by the household sector. Firewood and chips continue to be the main fuel in both urban and rural areas. While the monthly per capita consumption of firewood and chips has increased in rural areas, it has declined in urban areas between 1987/88 and 1993/94 (Table III). The consumption of LPG is negligible in rural areas due to the absence of an effective supply net-

Table II Per capita annual consumption of selected fuels in households: 1950/51 to 1995/96

Year	*Electricity (kWh)*	*Motor spirit (kg)*	*Kerosene (kg)*	*Cooking gas (kg)*
1950/51	2.0	1.8	2.5	–
1960/61	3.4	1.9	4.5	–
1970/71	7.0	2.9	6.6	0.33
1980/81	13.5	2.3	6.3	0.59
1990/91	38.2	4.2	10.0	2.88
1994/95	53.0	4.6	9.9	3.80
1995/96	–	5.1	10.2	4.18

Source TERI (1998)

Table III Monthly per capita consumption

	Rural		*Urban*	
All India	*1987/88*	*1993/94*	*1987/88*	*1993/94*
Firewood and chips (kg)	16.24	17.27	7.40	6.09
Electricity (kWh)	1.30	2.27	7.18	9.67
Kerosene (litre)	0.57	0.68	1.29	1.42
LPG (kg)	0.01	0.04	0.39	0.88

Source NSSO (1997a)

work in rural areas. Only 1.3% of the rural households use LPG as fuel for cooking, as against 27.2% of the urban households for the same purpose (Tables 27 and 28).

Rural

The consumption of energy for lighting is very low since a majority of the households use kerosene lamps. The household sector being the most prominent in rural areas accounts for nearly 75% of the total energy consumption. It has been estimated that within the household sector, cooking accounts for over 90% of the energy consumed (Natarajan 1985). In most parts of the country, rural households use traditional mud stoves, which are highly inefficient.

It is estimated that every year, about 200 million tonnes of fuelwood, 100 million tonnes of dungcakes, and 100 million tonnes of non-fodder crop residues are consumed as fuels in rural areas. During 1987/88 to 1993/94, the monthly per capita consumption of firewood increased from 16 kg to 17 kg (Table III). Firewood still remains the major fuel in rural areas; the consumption of other substitute fuels is negligible.

The NCAER also provides trends in rural energy consumption over the past 15 years. The consumption of firewood has gone up significantly and a definite shift from other fuels to firewood has taken place (Table 17).

Urban

During 1987/88 to 1993/94, the monthly per capita consumption of firewood and chips in urban areas declined from 7.4 kg to 6.1 kg (Table III). The use of soft coke has also declined, but this may be due to its decreasing supplies. The use of kerosene and LPG has increased substantially, the latter particularly in the higher-income households. The switchover had become possible in urban areas because of two reasons: (1) the biomass-based fuels have to be purchased and (2) the subsidies provided to kerosene and LPG. In 1993/94, the all-India cost estimates for urban areas are 5.12 rupees/kg for firewood, 5.49 rupees/litre for kerosene, and 5.94 rupees/kg for LPG.

In urban areas, the LPG consumption increased at nine per cent a year between 1990/91 and 1994/95. During the same period, the consumption of kerosene rose by 3%, and electricity by 11%. In 1991/92, the total commercial energy consumption in the household sector was estimated at 13 million tonnes of oil equivalent, which was 10% of the total consumption.

End-use energy consumption

The projections of the Planning Commission for the Ninth Plan and perspective period up to 2011/12 for the domestic sector are based on the year 1994/95. The energy demand estimates for lighting and cooking in the BAU (business as usual) scenario, which assumes energy efficiency to increase at the rate of 0.5%–1% a year, have been enlisted below. End-use methodology has been used to arrive at energy demand forecasts (Planning Commission 1998).

A GDP growth rate of 6.5% has been projected for the Ninth Plan, 7.7% for the Tenth Plan and 8% for the Eleventh Plan, with an average of 7.4% a year for the 15-year period. The population is expected to increase from 846 million in 1991 to 1178 million in 2011. Of this, the urban population is projected to grow from 217 million in 1991 to 377 million in 2011. While the urban households are expected to grow by 2.7% a year during 1994–2011, the rural households are projected to multiply by 1.5% over the same period.

Lighting

The use of electricity for lighting in India has increased by 22% in rural areas and by about 19% in urban areas during 1983–93. There is a commensurate decline in the number of households using kerosene for lighting in both rural and urban areas (Figures 5 and 6). Electrification of rural households has recorded more than twofold increase (from 14% in 1981 to 31% in 1991), whereas it is 14% in the case of urban households (Table 2).

The Planning Commission analysis assumes a 30% share for lighting, 5% for cooking, 20% for water heating, and 45% for others, for the base year 1994/95. The electricity consumption in the perspective period depends on the rate at which household electrification takes place and the growth in the household energy consumption. Household electrification is assumed to follow an S-curve path and it is also assumed that the new connections provided to households after 1994/95 are efficient ones. Old connections are substituted by efficient ones within a period of 20 years. The efficiency of lighting devices is also assumed to increase through a shift from the use of incandescent bulbs to fluorescent tubes to the use of compact fluorescent lamps.

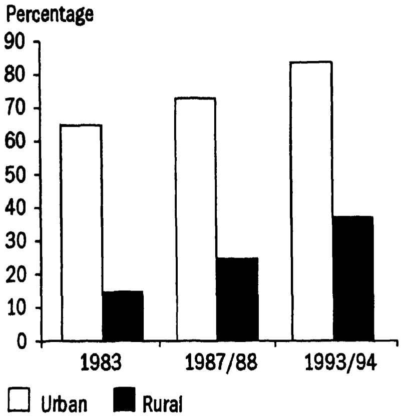

Figure 5 Households using electricity for lighting
Source NSSO (1997)

The percentage of electrified households out of the total households is projected to increase from 33 in 1994/95 to 59 in 2011/12. The electricity demand for the household sector is expected to increase from 95.84 TWh in 2001/02 to 242.94 in 2011/12. Assuming fuel consumption of 21.01 kg a year for lighting, the kerosene oil demand is projected to decrease from 2.61 million tonnes in 2001/02 to 2.12 million tonnes in 2011/12.

Cooking

The dependence of households on firewood and dungcake is on a decline in both rural and urban areas over the decade 1983–93 (with the exception of firewood in rural areas which has remained constant) (Figures 7 and 8). Firewood is the most prevalent primary source of energy for cooking used by rural households (78%). The use of kerosene and gas has increased although the effect is more pronounced in urban areas than in rural areas (Figures 9 and 10). Surprisingly, firewood and chips and gas (including LPG) are the two equally preferred energy sources used by the same proportion (around 30%) of urban households for cooking.

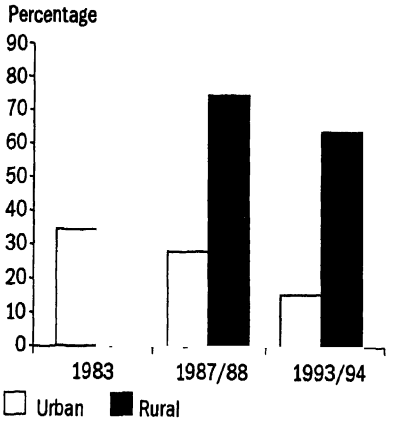

Figure 6 Households using kerosene for lighting
Source NSSO (1997)

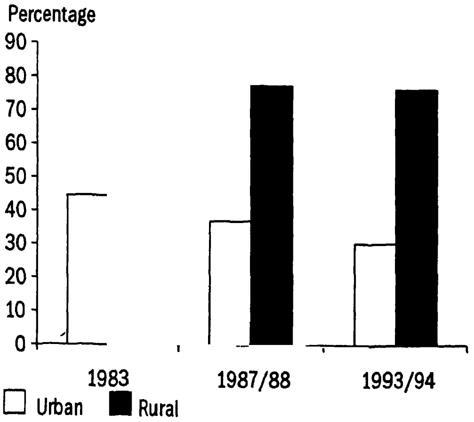

Figure 7 Households using firewood for cooking
Source NSSO (1997)

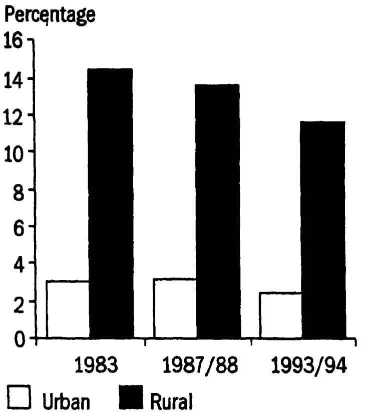

Figure 8 Households using dungcake for cooking
Source NSSO (1997)

Based on the estimates of ABE (1985) and the EDSG (1986), the Planning Commission estimates that the useful energy required per person per day in 2004/05 for cooking and space heating is 650 kcal for urban households and 520 kcal for rural households. This is based on the growth in useful energy consumption observed during 1960–76. However, for rural households, the per capita useful energy requirement per day is allowed to increase beyond the year 2004/05 at the rate at which it has increased in the past.

In addition, it is also assumed that electric devices will get replaced by solar energy appliances, used for water heating and cooking. The efficiency of fuelwood is expected to increase by one per cent over the base year in view of the improved chulhas and cookstoves, which are now being widely used (Table 20).

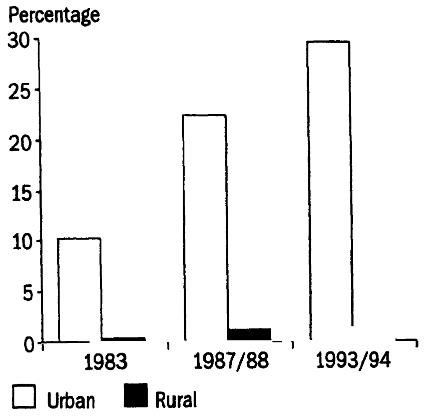

Figure 9 Households using gas for cooking
Source NSSO (1997)

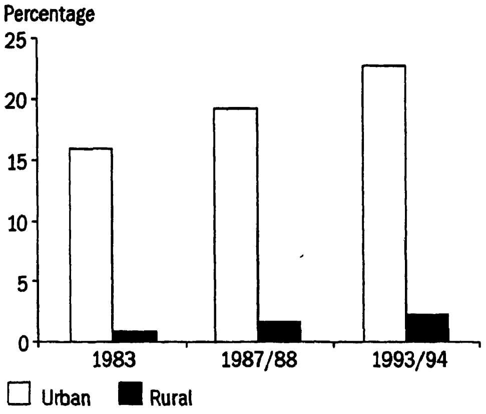

Figure 10 Households using kerosene for cooking
Source NSSO (1997)

The share of LPG in the total useful energy consumption for cooking is projected to increase both in urban and rural areas. In urban households, the share of LPG is expected to increase from 37.4% in 1994/95 to 72.8% in 2011/12. Likewise, LPG requirement in rural areas is expected to increase by 25% in 2019/20 from a meager use of 0.05 million tonnes in 1997/98.

While the demand for fuelwood is expected to decline from 174.83 million tonnes in 2001/02 to 171.14 million tonnes in 2011/12, the demand for LPG is expected to increase by nearly nine per cent a year from 5.5 million tonnes in 2001/02 to 13.23 million tonnes in 2011/12 (Table 21). The energy requirement of kerosene would decline progressively due to its substitution by electricity for lighting and greater penetration of LPG for cooking in the domestic sector. Though the consumption of coal has been projected to increase, in reality it has been declining. This has led to an increased dependence on fuelwood in rural areas, the share of which in cooking has gone up from 56% in 1989/90 to nearly 62% in 1994/95.

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Table 1

Consumer's monthly per capita expenditure on fuel and light (%)

State	*32nd round (July 1977–June 1978)*		*38th round (January–December 1983)*		*43rd round (July 1987–June 1988)*		*50th round (1993/1994)*	
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
Andhra Pradesh	5.22	5.54	5.96	6.04	6.24	5.90	5.94	6.13
Assam	7.32	5.59	7.91	7.18	8.01	24.87	7.69	5.84
Bihar	5.44	5.41	6.68	6.48	7.63	6.67	7.73	7.05
Gujarat	5.81	5.75	7.22	6.97	8.16	8.26	7.74	7.11
Haryana	4.50	5 37	6.53	6.87	6.37	6.93	5.91	6.70
Himachal Pradesh	8.16	7.20	8.96	6.50	21.25	6.79	7.77	4.29
Karnataka	6.67	6.47	8.22	7.04	8.64	7.37	8.09	7.41
Kerala	5.60	6.14	5.82	5.70	6.40	6.02	5.74	5.54
Madhya Pradesh	5.92	3.57	6.99	7.17	7.60	6.42	9.73	6.54
Maharashtra	5.05	6.08	8.30	6.92	7.53	6.54	7.38	6.78
Orissa	6.81	5.53	5.88	6.84	9.07	7.13	9.23	7.43
Punjab	5.79	5.52	6.82	8.10	7.25	7.61	7.74	7.65
Rajasthan	4.07	5.65	7.50	6.74	7.28	6.27	8.29	6.80
Tamil Nadu	6.40	6.50	6.75	6.29	6.70	6.10	5.99	6.38
Uttar Pradesh	5.83	6.11	7.84	8.00	7.69	7.55	6.95	7.09
West Bengal	5.74	5.40	6.64	6.68	7.34	7.47	7.05	7.27
India	**5.56**	**5.71**	**7.08**	**6.82**	**7.44**	**6.69**	**7.35**	**6.60**

Sources

1. NSSO. 1991. Sarvekshana Vol. XIV No 3. Issue no. 46 (January–March 1991) (For July 1977–June 1978 and January–December 1983); Vol. XV No. 1. Issue no. 48 (July–September 1991) (For July 1987–June 1988). New Delhi: National Sample Survey Organization, Department of Statistics, Ministry of Planning, Government of India.
2. NSSO. 1996. Sarvekshana Vol. XIX No. 3. Issue no. 66 (January–March 1996) (For 1993/94). New Delhi: National Sample Survey Organization, Department of Statistics, Ministry of Planning, Government of India.

Table 2

Households having electricity connection (%): 1981 and 1991

State/union territory	*1981*			*1991*		
	Total	*Rural*	*Urban*	*Total*	*Rural*	*Urban*
State						
Andhra Pradesh	21.41	12.53	52.22	46.30	37.50	73.31
Arunchal Pradesh	15.15	10.99	64.26	40.85	33.88	80.96
Assam	—	—	—	18.74	12.44	63.21
Bihar	9.20	3.48	50.90	12.57	5.57	58.77
Delhi	73.57	51.68	74.94	79.48	59.85	81.38
Goa	58.08	52.52	69.97	84.69	81.82	88.77
Gujarat	44.81	30.83	74.40	65.93	56.43	82.96
Haryana	51.53	41.04	82.22	70.35	63.20	89.13
Himachal Pradesh	54.86	51.08	89.36	87.01	85.86	96.24
Jammu and Kashmir	60.87	52.24	92.18	—	—	—
Karnataka	32.98	21.35	91.98	52.47	41.75	76.27
Kerala	28.78	23.21	54.57	48.43	41.95	67.65
Madhya Pradesh	17.11	6.89	56.42	43.30	34.49	72.52
Maharashtra	40.65	24.12	70.53	69.40	58.45	86.07
Manipur	20.06	10.28	48.32	50 92	41.73	75.45
Meghalaya	16.84	7.44	59.59	29.16	16.34	83.04
Mizoram	16.27	4.96	50.06	59 20	35.47	85.50
Nagaland	26.12	19.97	58.43	53.42	47.16	75.58
Orissa	17.75	13.03	51.74	23.54	17.45	62.11
Punjab	60.90	50.61	85.44	82.31	76.98	94.60
Rajasthan	20.54	8.70	63.67	35.03	22.44	76 67
Sikkim	23.11	13.01	71.80	60.66	57.12	92.37
Tamil Nadu	37.21	26.03	61.59	54.74	44.49	76.80
Tripura	25.05	16.52	92.10	36 93	28.50	80.43
Uttar Pradesh	12.91	3 97	54.61	21.91	10.96	67.76
West Bengal	21.09	7.02	57.86	32.90	17.75	70.19
Union territory						
Andaman and Nicobar Islands	35.92	19.87	78.22	63.52	53.62	90.55
Chandigarh	84.43	67.85	85.48	83.12	65.25	85.48
Dadra and Nagar Haveli	28.66	25.87	67.66	54.42	51.20	87.57
Daman and Diu	78.33	73.48	85.89	94.13	92.87	95.46
Lakshadweep	91.79	88.01	96.35	98.46	97.65	99.11
Pondicherry	43.79	28.97	58.11	63.58	51.20	71.71
India	**26.19**	**14.69**	**62.51**	**42.37**	**30.54**	**75.78**

Source

GoI. 1995 Housing and Amenities Occasional Paper No 5 of 1994 Census of India 1991. New Delhi Government of India

Table 3

All-India purchases of durable products (million) (rural and urban): 1985/86 to 1995/96

Product	*1985/86*	*1989/90*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Bicycle	4.700	5.692	7.078	8.131	7.500	8.016
Cassette recorder	1.300	3 430	5.450	5.880	6.466	6.991
Electric iron	1.300	1.600	2.000	2.360	2.614	2.885
Fan (ceiling)	3.080	2.500	4.710	5.210	6.025	7.085
Fan (table)	1.700	1.300	2.260	5.740	3.150	3.196
Geyser (instant)	—	0.120	0.168	0.126	0.180	0.196
Geyser (storage)	—	0.077	0.084	0.249	0.265	0.321
Mixer/grinder	0.800	1.500	1.680	1.750	1.850	1.974
Motorized two wheeler (moped)	0.429	0.500	0.405	0.449	0.545	0.716
Motorized two wheeler (motor cycle)	0.199	0 340	0.358	0.436	0.454	0.535
Motorized two wheeler (scooter)	0.480	0.718	0.730	0.840	0.901	1.217
Pressure cooker	2.200	3.100	3.390	0.326	3.501	3.980
Pressure pan	*	*	*	0.264	0.308	0.388
Radio/transistor	3.200	5 000	4.730	4.490	4.935	5.400
Refrigerator	0.560	1.090	1.190	1.470	1.608	1.995
Sewing machine	0.980	0.500	0.550	0.590	0.650	0.719
TV (B&W)	1.400	4 000	3.390	3.900	4.645	5.988
TV (colour)	0.600	1.200	0.830	1.280	1.392	1.747
VCR/VCP	0.080	0 420	0.130	0.150	0.186	0.204
Washing machines	0.110	0.290	0.520	0.790	0.970	1.134
Wrist watch (mechanical	6.200	10.900	10.890	10.560	8.397	9.018
Wrist watch (quartz)	2.500	7 300	7.850	8.020	8.743	10.242

included under pressure cooker

Source

Natrajan I 1998 India Market Demographics Report 1998 New Delhi National Council of Applied Economic Research.

Table 4

Purchases of durable products (rural share) (%): 1985/86 to 1995/96

Product	*1985/86*	*1989/90*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Bicycle	82.00	73.82	78.09	77.75	78.95	78.08
Cassette recorder	47.00	42.77	49.06	53.45	54.75	55.03
Electric iron	46.00	43.00	34.45	42.18	43.81	43.45
Fan (ceiling)	46.00	45.00	46.10	48.09	48.97	50.36
Fan (table)	60.73	58.00	60.78	64.98	64.55	65.89
Geyser (instant)	—	1.60	0.15	0.87	2.62	2.04
Geyser (storage)	—	2 58	4.31	0.95	1.49	1.55
Mixer/grinder	18.00	21.00	23.16	24.57	26.93	27.43
Motorized two wheeler (moped)	42.00	42.94	39.59	41.53	42.03	39.27
Motorized two wheeler (motor cycle)	52.00	51.00	47.66	49.09	47.54	47.87
Motorized two wheeler (scooter)	36 00	27.74	27.83	29.50	32.71	28.56
Pressure cooker	34.00	37.00	45 14	46.13	51.28	51 51
Pressure pan	*			17.98	15.50	19.45
Radio/transistor	79.00	78.39	79.43	78.61	78.74	79.20
Refrigerator	14.00	15.00	18.07	20.15	24.38	24.30
Sewing machine	60.00	56.00	63.72	64 29	66.40	64.34
TV (B&W)	26 00	44.00	47.70	57.11	59.44	62.65
TV (colour)	11.00	19 00	31.10	30.90	31.72	28.77
VCR/VCP	4.85	4.58	7.82	7.98	10.31	24.87
Washing machines	12.00	7.00	9.93	12.30	14.02	14.64
Wrist watch (mechanical	78.00	71.00	72.14	76.10	76.64	75.59
Wrist watch (quartz)	59.00	47.00	51.57	50.30	52.08	54.00

included under pressure cooker

Source

Natrajan I 1998 India Market Demographics Report 1998 New Delhi National Council of Applied Economic Research.

Table 5

Distribution of households (rural and urban) by fuel used (%)

Fuel	Rural				Urban			
	1974	*1979*	*1991* *	*1991* †	*1974*	*1979*	*1991* *	*1991* †
Coal/soft coke	—	3.51	1.54	—	26.60	28.00	8.95	—
Kerosene	6.80	6.10	1.34	—	10.90	40.00	23.62	—
Firewood	64.20	35.10	71.69	—	47.00	40.00	32.74	—
Liquefied petroleum gas	0.80	1.10	1.22	—	4.00	10.00	26.93	—
Biogas	—	1.00	0.43	—	—	—	0.68	—
Electricity	—	14.30	0.16	30.54	—	63.40	0.72	75.78
Cowdung	—	59.10	19.60	—	—	26.60	3.51	—

* fuel used by households only for cooking

† households having electricity connection

Sources

1. NCAER. 1981. Domestic Fuel Survey with Special Reference to Kerosene (1978/79). New Delhi: National Council for Applied Economic Research.
2. GoI. 1979 National Sample Survey 1973/74, 28th round. Report of the Working Group on Energy Policy. New Delhi: Government of India.
3. GoI. 1995. Housing and Amenities. Census of India 1991. Occasional Paper No. 5 of 1994. New Delhi: Government of India.

For more details, please see TEDDY ONLINE+ [Section: Residential (general)]

Table 6

Rural households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%)

MPCE Class (rupees)	*No cooking arrangement*	*Coke and coal*	*Firewood and chips*	*Gas (coal,oil or liquefied petroleum gas)*	*Gobar gas*	*Dungcake*	*Charcoal*	*Kerosene*	*Others*	*All*
Less than 120	1.4	0.7	79.1	0.1	0.1	10.1	—	—	8.6	—
120–140	0.4	0.7	80.9	0.2	—	12.3	—	—	5.5	—
140–185	0.3	0.9	81.0	0.1	—	12.2	—	0.2	5.2	—
185–190	0.3	1.1	82.1	0.1	0.1	11.2	—	0.6	4.6	—
190–210	0.6	0.9	81.1	0.4	0.1	11.9	—	0.5	4.4	—
210–235	0.4	1.0	81.8	0.3	0.1	11.7	—	0.9	3.9	—
235–265	0.4	1.4	81.4	0.5	0.2	11.7	—	0.9	3.5	—
265–300	0.2	1.6	80.2	1.1	0.3	11.7	—	1.3	3.5	—
300–355	0.6	1.7	79.9	1.3	0.4	10.8	—	2.2	3.0	—
355–455	1.1	1.7	75.0	2.9	0.7	12.2	0.1	3.7	2.5	—
455–560	0.8	2.0	71.6	8.0	1.0	11.3	—	4.8	2.2	—
580 and above	2.8	2.0	58.2	12.4	1.2	11.0	0.1	10.1	2.2	—
All classes	0.7	1.4	78.2	1.9	0.3	11.5	—	2.0	3.8	—
Estimated households (hundreds)	8335	16186	934591	22665	4048	137840	433	24386	45849	1194669
Sample households	373	918	54892	1976	385	7056	29	1437	2117	69206

Source
NSSO. March 1997 Energy Used by Indian Households Report No 410/2. New Delhi. National Sample Survey Organization Department of Statistics, Government of India.

Table 7

Urban households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%)

MPCE Class (Rs)	*No cooking arrangement*	*Coke and coal*	*Firewood and chips*	*Gas (coal,oil or liquefied petroleum gas)*	*Gobar gas*	*Dungcake*	*Charcoal*	*Kerosene*	*Others*	*All*
Less than 160	9.3	5.6	67.9	2.0	0.1	4.8	0.1	7.3	2.8	—
160–190	3.1	6.8	65.7	2.2	—	4.0	—	14.3	3.6	—
190–230	3.0	7.7	81.8	5.4	—	3.3	0.1	15.5	3.2	—
230–265	2.2	8.3	53.3	8.0	—	4.7	0.5	19.8	3.2	—
265–310	2.0	7.4	45.0	14.7	0.1	2.4	0.4	24.9	3.2	—
310–355	1.4	8.3	36.0	20.7	0.2	3.0	0.3	27.1	2.9	—
365–410	3.5	7.0	28.0	27.5	—	2.3	0.3	28.7	2.7	—
410–490	4.9	6.3	21.5	32.8	0.2	1.7	0.3	29.6	2.7	—
490–805	7.6	4.0	14.7	40.7	—	2.0	0.3	27.9	2.6	—
805–825	9.6	3.9	9.3	49.4	0.2	1.3	0.2	24.1	1.8	—
825–1065	13.3	2.2	4.9	53.7	—	1.0	—	23.0	1.7	—
1055 and above	16.4	1.5	3.3	60.5	0.2	0.6	—	15.9	1.2	—
All classes	6.3	5.7	29.9	29.5	0.1	2.4	0.2	23.2	2.6	—
Estimated households (hundreds)	27134	24627	129175	128065	408	10175	1058	100495	11119	432603
Sample households	2030	2479	14144	15414	43	1005	144	9886	973	46148

Source
NSSO March 1997 Energy Used by Indian Households. Report No 410/2. New Delhi National Sample Survey Organization. Department of Statistics, Government of India

Table 8

Consumption of fuel – rural (states) (rupees): 1983/84 and 1993/94

	Traditional				*Commercial*					
	Firewood and chips		*Dungcake*		*Kerosene*		*Liquefied petroleum gas*		*Electricity*	
State	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*
Andhra Pradesh	4.48	10.51	0.42	0.37	1.11	2.37	0.03	0.40	0.31	2.60
Assam	6.55	14.29	0.03	0.59	1.83	2.94	0.02	0.21	0.10	0.96
Bihar	2.34	6.93	1.88	5.08	1.06	2.69	0.02	0.04	0.03	0.33
Gujarat	6.13	11.02	0.57	1.66	1.50	3.61	0.01	0.60	0.75	5.15
Haryana	3.23	7.47	3.40	5.63	1.10	1.80	0.01	0.52	0.85	6.01
Karnataka	7.13	14.35	0.39	0.82	1.33	2.75	0.04	0.29	0.32	2.19
Kerala	6.15	14.97	0.01	0.01	1.03	2.07	0.01	0.88	0.78	3.04
Madhya Pradesh	4.30	16.24	1.25	3.56	1.00	1.87	0.01	0.06	0.18	2.05
Maharashtra	5.79	9.75	0.83	1.29	1.40	2.95	0.05	0.56	0.55	3.66
Orissa	4.23	13.23	0.61	1.50	1.08	2.24	—	0.03	0.24	1.86
Punjab	4.27	8.88	3.89	8.76	1.07	2.74	0.02	0.92	1.51	10.51
Rajasthan	4.44	15.55	1.20	4.59	0.89	1.80	0.02	0.26	0.17	2.78
Tamil Nadu	5.42	10.36	0.19	0.19	1.09	3.07	0.01	0.69	0.55	2.69
Uttar Pradesh	3.32	7.94	3.24	6.45	1.01	2.52	0.01	0.20	0.05	0.85
West Bengal	2.84	7.85	0.97	3.51	1.21	3.11	0.02	0.05	0.10	0.81
All India	**4.40**	—	**1.40**	—	—	—	—	—	**0.32**	—

Source

NSSO. March 1997. Energy Used by Indian Households. Report No. 410/2. New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.

Table 9

Consumption of fuel – urban (states) (rupees): 1983/84 and 1993/94

	Traditional				*Commercial*					
	Firewood and chips		*Dungcake*		*Kerosene*		*Liquefied petroleum gas*		*Electricity*	
State	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*
Andhra Pradesh	3.90	5.91	0.19	0.21	2.40	5.08	0.75	5.20	1.61	7.37
Assam	6.47	8.19	0.03	0.03	2.14	4.56	0.58	7.22	1.42	5.07
Bihar	1.86	3.25	0.72	1.89	1.30	3.82	0.25	3.55	0.96	6.06
Gujarat	1.98	2.78	0.21	0.49	3.34	5.87	1.06	7.28	2.95	14.49
Haryana	2.76	4.28	1.47	1.94	2.39	4.03	1.22	7.52	2.79	12.23
Karnataka	5.59	7.57	0.29	0.28	3.02	7.23	0.53	4.79	1.84	10.24
Kerala	5.59	14.05	0.02	0.01	1.21	2.62	0.75	3.73	1.84	5.58
Madhya Pradesh	4.25	6.57	0.45	1.08	1.73	3.58	0.61	5.90	1.65	7.80
Maharashtra	2.46	2.32	0.16	0.17	4.14	7.27	1.73	7.38	3.65	16.48
Orissa	6.03	9.56	0.20	0.38	1.25	4.20	0.24	4.09	1.48	9.27
Punjab	2.62	2.40	1.71	1.90	3.60	5.92	0.91	9.14	4.75	18.10
Rajasthan	4.56	7.24	0.83	1.65	1.93	4.04	0.27	4.93	1.70	9.63
Tamil Nadu	4.42	7.07	0.24	0.18	2.74	7.79	0.68	4.29	1.86	7.84
Uttar Pradesh	4.25	5.90	0.09	2.16	1.73	3.93	0.66	5.51	1.67	8.43
West Bengal	0.75	1.56	0.87	1.89	1.82	5.91	0.41	5.19	2.35	10.71
All India	**3.45**	—	**0.53**	—	**2.54**	—	**0.85**	—	**2.29**	—

Source

NSSO March 1997. Energy Used by Indian Households Report No. 410/2 New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.

Table 10

Conversion efficiency of fuels used for cooking (%)

Fuel	*Efficiency*
Commercial	
Soft coke/coal	10
Kerosene (in pressure stoves)	40
Kerosene (in wick stoves)	36
Liquefied petroleum gas	60
Electric hotplates	71
Non-commercial fuels	
Firewood (closed hearth)	16
Firewood (open hearth)	13
Twigs and straw (closed hearth)	16
Twigs and straw (open hearth)	13
Charcoal	16
Dungcakes	8
Biogas stove	55

Sources

1 BIS. 1984. New Delhi Bureau of Indian Standards

2. Ravindranath N H, Ramakrishna J. 1997. Energy options for cooking in India Energy Policy, 25(1): 63–75.

Table 11

All-India estimates of commercial energy consumption in the domestic sector: 1980/81 to March 1997

	Fuel	*1980/81*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*		*1995/96*	*1996*	*1997 (March)*
£	Liquefied petroleum gas (million tonnes) **	0.33	1.89	2.13	2.28	2.42	2.76		3.09	2.45	3.36
#	Kerosene (million tonnes) **	3.38	6.74	6.70	6.78	6.96	7.17		7.49	5.77	8.10
	Electricity (GWh)	9247	31982	35923	39717	43344	47703	*	—	—	—

* provisional figure

** estimated consumption based on the TERI study and the National Council for Applied Economic Research Survey

£ liquefied petroleum gas (percentage share of domestic sector in total consumption) 80%

kerosene (percentage share of domestic sector in total consumption): 85%

Sources

1 MoPNG. 1997 Annual Report 1996/97. New Delhi Ministry of Petroleum and Natural Gas

2 CEA 1996. Power Supply Industry in India Highlights New Delhi Central Electricity Authority

Table 12

Annual per capita energy consumption in rural and urban areas: 1973/74 and 1978/79

Fuel	*Rural*		*Urban*	
	1973/74	*1978/79*	*1973/74*	*1978/79*
Commercial				
Coal/soft coke (kg)	6.80	2.30	33.40	31.30
Kerosene (litre)				
For lighting	—	4.30	—	2.60
For cooking	—	0.80	—	9.00
Total	**8.80**	**5.10**	**14.00**	**11.60**
Liquefied petroleum gas (kg)	—	0.01	—	2.20
Electricity (kWh)	2.20	4.90	18.20	35.00
Traditional fuels (kg)				
Fuelwood	251.90	40.90	148.60	82.00
Charcoal	0.10	0.20	2.60	3.80
Dungcakes	72.70	133.10	25.20	35.70
Other solid fuels	12.40	176.90	3.50	4.90

also includes water heating and space heating

includes crop wastes, sawdust, woodshavings, twigs, leaves, etc.

Sources

1. Fuel Policy Commission Report. 1974 New Delhi.
2. NCAER. 1981. Domestic Fuel Survey with Special Reference to Kerosene (1978/79). New Delhi: National Council for Applied Economic Research.

Table 13

Change in energy consumption in the household sector: 1970/71 and 1982/83

Fuel	*1970/71*	*1982/83*	*Change (%)*	*Composition (%)*	
				1970/71	*1982/83*
Commercial					
Coal (million tonnes)	3.20	4.60	45.00	1.70	1.80
Oil (million tonnes)	3.70	5.70	55.00	4.00	4.60
Electricity (TWh)	3.80	12.00	211.00	0.40	0.80
Total (million tonnes of oil equivalent)	**5.60**	**9.10**	**61.00**	**6.10**	**7.20**
Non-commercial					
Firewood (million tonnes)	117.90	154.00	31.00	60.70	58.60
Crop residue (million tonnes)	36.30	40.00	10.00	16.40	13.50
Dungcake (million tonnes)	64.60	109.00	69.00	16.80	20.70
Total	**86.50**	**115.80**	**34.00**	**93.90**	**92.80**
Grand total (million tonnes of oil equivalent)	**92.20**	**124.80**	**35.36**	**100.00**	**100.00**

Sources

1. GoI. 1979. Report of the Working Group on Energy Policy. New Delhi: Government of India.
2. Planning Commission 1985. Report of the Advisory Board on Energy. New Delhi· Government of India.

Table 14

Annual consumption of biofuels in rural households (million tonnes)

	Firewood			*Dungcake*			*Agricultural residues*		
State/union territory	*REDB India * 1992*	*IREP ‡ 1992*	*NCAER § 1985*	*REDB India 1992*	*IREP 1992*	*NCAER 1985*	*REDB India 1992*	*IREP 1992*	*NCAER 1985*
Andhra Pradesh	23.20	10.80	9.70	9.50	2.90	2.30	18.60	3.60	1.80
Arunachal Pradesh	0.50	0.50	0.10	0.10	—	—	0.10	—	0.10
Assam	13.70	12.30	2.30	1.40	—	—	2.70	—	1.50
Bihar	34.10	26.90	8.90	8.20	9.90	19.90	7.80	13 00	6.00
Goa	—	—	0.10	—	—	0.70	—	—	—
Gujarat	8.60	9.10	4 00	2 30	2.20	2.50	3.00	3.00	0.20
Haryana	1.70	1.70	0.60	2.60	2.90	3.10	1.50	4.30	1.00
Himachal Pradesh	1.80	3.30	2.20	0.30	0.40	—	—	0.20	—
Karnataka	10.60	8.30	6.70	2.60	1.80	0.30	7.80	3.20	1.60
Kerala	7.40	10.00	3.20	1.20	—	—	1.00	1.60	1.80
Madhya Pradesh	32.60	13.10	8.70	6.20	1.80	9 60	5.70	1.50	2.30
Maharashtra	20.00	16.00	5.50	2.90	6.70	4.30	7.60	5.80	0.70
Manipur	0.90	0.80	0.40	0.10	—	—	0 20	—	0.10
Meghalaya	1.00	0.90	0.40	0.10	—	—	0.20	—	0.10
Mizoram	0.30	0.20	0.10	—	—	—	0.10	—	—
Nagaland	0.70	0.60	0.30	0.10	—	—	0.10	—	0.10
Orissa	26.00	11.20	4.60	4.30	0.60	3.30	7.60	0 40	0.80
Punjab	1.90	1.90	1.30	3.00	3.40	3.00	1.80	5.00	1.60
Rajasthan	9.80	4.30	7.10	7.80	2.10	4.80	2.80	0.80	0.50
Sikkim	0.30	0.20	—	—	—	—	0.10	—	—
Tamil Nadu	17.90	8.50	6.30	7 50	2.00	1.50	13.90	2 50	1.50
Tripura	1.60	1 40	0.70	0.20	—	—	0.30	—	0.20
Uttar Pradesh	16.60	21.90	15.60	37.20	17.20	23 50	5 60	17 30	7.00
West Bengal	20.30	4.40	4.50	9.00	—	4.90	10.50	—	7.70
† Union territories	0.40	0.40	0.20	0.40	0.30	0.20	0.30	0.40	0.10
All-India	**251.90**	**168.70**	**93.50**	**107.00**	**54.20**	**83.90**	**99.30**	**62.60**	**36.70**

* Rural Energy Database - India of TERI

† includes the total of all union territories

‡ Integrated Rural Energy Programme

§ National Council of Applied Economic Research

Sources

1. TERI 1992. Rural Energy Database - India. New Delhi. Tata Energy Research Institute
2. NCAER 1981. Domestic Fuel Survey with Special Reference to Kerosene (1978/79). New Delhi: National Council of Applied Economic Research
3. Planning Commission 1997. Eighth Five Year Plan, 1992–97. New Delhi: Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Residential (fuel energy/consumption)]

Table 15

National aggregates of biofuel use in the rural domestic sector (million tonnes per year)

Source	Firewood	Dungcake	Agricultural residue
Consumption			
National Council of Applied Economic Research. - 1985	93.3	83 2	36 7
Rural Energy Database (TERI) - 1992			
Low	181.3	40.1	31.6
Average	252.1	106.9	99.2
High	309 4	114.5	165.5
Integrated Rural Energy Programme - 1992	169 0	54.2	62 8
£ **Requirement**			
Energy Survey of India (510 or 2.13) - 1965	151 3	41.5	47.8
Advisory Board on Energy (620 or 2.60) - 1985	240.5	65.9	76 0
Energy Demand Screening Group (520 or 2.18) - 1986	201 7	55.3	63 7

£ in kcal/capita/day or in MJ/capita/day

Sources

1 Planning Commission 1965 Report of the Energy Survey of India Committee New Delhi. Planning Commission, Government of India
2. Planning Commission 1985. Report of the Advisory Board on Energy. New Delhi· Planning Commission, Government of India
3 Planning Commission. 1986 Report of the Energy Demand Screening Group New Delhi Planning Commission, Government of India.
4 NCAER. 1985. Domestic Fuel Survey with Special Reference to Kerosene (1978/79) New Delhi National Council for Applied Economic Research
5. TERI 1992 Rural Energy Database - India. New Delhi· Tata Energy Research Institute

Table 16

Daily per capita consumption of biofuels in rural households in different agroclimatic zones (kg): 1992

Agroclimatic zones	Firewood		Crop residue		Dungcake	
	IREP	REDB - India	IREP	REDB - India	IREP	REDB - India
Western Himalayas	1 95	1 09	0.10	—	0 22	0 17
Eastern Himalayas	1.70	1 90	—	0 37	—	0 20
Middle Gangetic plains	0 75	0.45	0 70	0 30	0 50	0 41
Upper Gangetic plains	0 36	0 29	0 40	0 04	0 43	1.29
Trans-Gangetic plains	0 37	0 38	1 00	0 34	0 65	0 57
Eastern plateau and hills	1.60	3.36	—	0.24	—	0 01
Western plateau and hills	0.79	0 94	0 40	0 50	0 47	0 18
Southern plateau and hills	0 62	0.94	0 30	0 82	0.19	0 25
East-coast plains and hills	0 60	1 78	0.10	1 35	0.13	0.91
West-coast plains and hills	1.29	0.94	0.20	0 12	—	0.16
Gujarat plains and ghats	0 92	0 87	0 30	0 31	0 22	0 23
Western dry region	1 08	0.57	—	0.13	0 44	0 61
Lower gangetic plains	—	0.93	—	0.62	—	0 56
Central plateau and hills	—	0 95	—	0.26	—	0.65
All-India	—	**1.22**	—	**0.47**	—	**0.40**

REDB - Rural Energy Database - India of TERI
IREP - Integrated Rural Energy Programme

Sources

1 Planning Commission 1997 Eighth Five Year Plan, 1992–97, Vol 2 New Delhi Planning Commission, Government of India.
2 TERI 1992. Rural Energy Database - India New Delhi Tata Energy Research Institute

Table 17

Energy consumption in rural households: 1978/79 and 1992/93

Energy fuel	1978/79		1992/93	
	Quantity ('thousand tonnes)	Percentage share (useful kcal)	Quantity ('thousand tonnes)	Percentage share (useful kcal)
Coal/soft coke	1143	1 92	429	0 38
Kerosene	414 *	2.55	1103 *	4.44
Dungcake	66755	22 51	86732	17.00
Firewood	—	—	—	—
Logs	20109	11 95	57956	32 49
Twigs	58742	35 62	73418	29.11
Crop waste	29529	17 41	34955	13 35
Others	—	1.03	—	—
Total	—	**100.00**	—	**100.00**

* in thousand kilolitres

Source

Natrajan I 1997 Biomass Energy Key Issues and Priority Needs Paris Organization for Economic Cooperation and Development.

Table 18

Monthly per capita fuel consumption in rural areas (states): 1993/94

State	*Traditional* Firewood and chips (kg)	Kerosene (litre)	*Commercial* Liquefied petroleum gas (kg)	Electricity (kWh)
Andhra Pradesh	18.84	0.64	0.05	3.16
Assam	23.05	0.80	0.03	0.34
Bihar	10.39	0.60	0.01	0.13
Gujarat	14.61	1.14	0 08	4.78
Haryana	15.07	0.57	0.07	5.57
Karnataka	23.62	0.70	0.04	2.62
Kerala	23.57	0.70	0.12	4.29
Madhya Pradesh	27.33	0.52	0.01	1.89
Maharashtra	13.75	0.84	0.08	4.47
Orissa	22.88	0.49	0.01	1.05
Punjab	13.47	0.82	0.12	8.48
Rajasthan	21.92	0.48	0.04	2.46
Tamil Nadu	16.99	0.84	0.10	4.04
Uttar Pradesh	12.54	0.58	0.03	0.43
West Bengal	12.36	0 82	0.01	0.93

Source

NSSO. March 1997. Consumption of some important commodities in India Report No 404. NSSO 50th Round 1993/94 New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.

Table 19

Monthly per capita fuel consumption in urban areas (states): 1993/94

State	*Traditional* Firewood and chips (kg)	Kerosene (litre)	*Commercial* Liquefied petroleum gas (kg)	Electricity (kWh)
Andhra Pradesh	7.69	1.29	0.74	8 46
Assam	11.03	1.11	1.09	2.33
Bihar	3.95	0.79	0.53	2.99
Gujarat	2.71	1 72	1 01	11.39
Haryana	5.32	1.11	1.11	12 12
Karnataka	9.51	1.79	0 68	10.54
Kerala	18.77	0.85	0.51	7 43
Madhya Pradesh	8.01	0.97	0.81	8.19
Maharashtra	2.61	2.15	1.17	15.35
Orissa	11.92	0.97	0.59	7 23
Punjab	3 21	1.54	1.31	15.35
Rajasthan	7.54	1.13	0.72	8.59
Tamil Nadu	7.96	1.82	0.65	10 08
Uttar Pradesh	6.55	0.92	0.83	5.46
West Bengal	1.95	1.38	0.74	10.19

Source

NSSO March 1997. Consumption of some important commodities in India Report No 404 NSSO 50th Round 1993/94. New Delhi: National Sample Survey Organization, Department of Statistics, Government of India

Table 20

Assumptions for projecting energy demand for cooking

Urban households	*Coal*	*Charcoal*	*Liquefied petroleum gas*	*Superior kerosene oil*	*Natural gas*	*Electricity*	*Fuelwood*	*Agricultural waste*	*Dungcake*
Efficiency (%)	25	25	60	50	50	27	9	8	8
Share in 1994/95 (%)	1.8	3.4	37.4	41.5	1.7	1.1	7.7	1.8	3.6
Rural households									
Efficiency (%)	25	25	60	50	50	27	9	8	8
Share in 1994/95 (%)	0.5	0	0	5.7	0	0	61.7	15.5	15.4

Source

Planning Commission 1998 Sectoral Energy Demand in the 9th Plan and the perspective period up to 2011–2012. A Technical Note. New Delhi. Planning Commission, Government of India.

Table 21

Projections for energy demand for cooking and lighting

	2001/02	*2006/07*	*2011/2012*
Liquefied petroleum gas MT (million tonnes)	5.50	9.62	13.23
Superior kerosene oil (MT)	8.22	6.69	5.57
Coal (MT)	1.71	1.98	2.22
Charcoal (MT)	2.32	2.76	3.13
Natural gas MCM (million cubic metres)	260.00	304.00	347.00
Fuel wood (MT)	174.83	174.34	171.14
Dung cake (MT)	96.80	97.44	100.04
Crop waste (MT)	59.10	63.16	67.87
Biogas (MCM	1 537.38	1 902.38	2 273.59

Source

Planning Commission. 1998. "Sectoral Energy Demand in the 9th Plan and the perspective period up to 2011–2012. A Technical Note. New Delhi: Planning Commission, Government of India.

Table 22

Projected annual consumption of different fuels by urban households of different income groups (per capita)

Annual household income (Rs)	Distribution of households (%)	All-India urban population, excluding slums (million)		Projected annual per capita consumption in 2001					
		1991	2001	Liquefied petroleum gas (kg)	Kerosene (litre)	Soft coke (kg)	Firewood (kg)	Dungcake (kg)	Electricity (kWh)
Up to 500	2.5	4.1	5.8	5.0	14.7	6.4	129.2	47.0	112.4
500–1000	47.4	76.4	108.3	12.2	15.6	13.6	113.9	23.6	127.8
1000–1500	27.6	44.4	62.9	18.3	14.0	19.7	91.2	30.9	185.8
Over 1500	22.4	36.1	51.2	36.0	7.8	3.7	24.5	3.8	445.7
All categories	**99.9**	**161.0**	**228.2**	—	—	—	—	—	—

Sources

1 TERI 1988 Report on Urban Household Energy Policy Submitted to the Advisory Board on Energy, Government of India New Delhi Tata Energy Research Institute

2 Sivaramakrishnan K C 1993 Managing Urban Environment in India. Towards an Agenda for Action Chapter 13, Volume 3 Industry, Energy, Transport and Air New Delhi. The Times Research Foundation

For more details, please see TEDDY ONLINE+ [Section: Residential (fuel energy/consumption)]

Table 23

Annual demand for different fuels: 1989/90 to 2004/05

Fuel	1989/90	1994/95	1999/2000		2004/05	
	EDSC *	EDSG	EDSG	SEDI †	EDSG	SEDI
Commercial						
Electricity (TWh)	26.6	46.9	82.6	77.9	145.6	132.8
Liquefied petroleum gas + Superior kerosene oil (million tonnes)	9.2	12.6	17.3	18.7	23.7	25.0
Coal (for soft coke) (million tonnes)	5.0	9.0	14.0	19.8	20.0	33.2
Kerosene (million tonnes)	—	—	—	12.7	—	15.5
Liquefied petroleum gas (million tônnes)	—	—	—	6.0	—	9.5
Charcoal (million tonnes)	—	—	—	4.4	—	6.7
Non-commercial						
Fuelwood (million tonnes)	—	145.0	117.3	—	61.3	—
Agricultural waste (million tonnes)	—	44.6	36.1	—	18.9	—
Dungcakes (million tonnes)	—	79.4	64.3	—	33.6	—
Non-commercial (million tonnes of oil equivalent	—	—	—	117.4	151.4	102.8

* Energy Demand Screening Group

† Sectoral Energy Demand for India

Sources

1 Planning Commission 1986 Report of the Energy Demand Screening Group New Delhi Planning Commission, Government of India

2 Planning Commission 1991 Sectoral Energy Demand for India New Delhi Planning Commission, Government of India

Table 24

Demand for heating energy and likely pattern of fuel use in rural households: 2001/02 and 2006/07

Fuel	*Unit*	*2001/02*		*2006/07*		
		Quantity	*Calorific replacement thousand tonnes*	*Quantity*	*Calorific replacement thousand tonnes*	*Share (%)*
Coal/soft coke	thousand tonnes	400	600	400	600	0.25
Kerosene	thousand kilo litres	1863	11551	2290	14198	6.06
Biogas	million cubic metres	1360	4760	2040	7140	3.05
Dungcake	thousand tonnes	94858	28457	98709	29613	12.64
Crop wastes	thousand tonnes	38959	23765	40882	24938	10.65
Firewood	thousand tonnes	17316	132875	210508 *	157748	67.35
Total		—	**202008**	—	**234237**	**100**

* assuming logs form 44.3% of total firewood

Source

Natrajan I 1997. Biomass Energy: Key Issues and Priority Needs. Paris: Organization for Economic Cooperation and Development.

Table 25

Primary source of energy for lighting in rural and urban households (%)

State	*Rural*				*Urban*			
	Kerosene		*Electricity*		*Kerosene*		*Electricity*	
	1988/89	*1993/94*	*1988/89*	*1993/94*	*1988/89*	*1993/94*	*1988/89*	*1993/94*
Andhra Pradesh	59.07	50.5	38.2	49.2	25.8	17.9	72.4	81.9
Assam	84.70	84.6	9.1	14.9	29.4	25.9	67.8	73.7
Bihar	92.20	92.8	4.4	6.4	38.4	34.3	59.6	65.3
Gujarat	42.20	31.8	49.4	67.5	12.5	9.5	83.1	89.7
Haryana	41.60	23.5	57.2	74.6	7.5	9.2	91.8	89.8
Karnataka	60.10	44.9	35.8	54.5	22.5	16.6	74.8	83.2
Kerala	55.90	43.4	42.2	56.5	28.1	21.1	70.1	78.4
Madhya Pradesh	62.30	54.1	29.8	44.9	23.3	11.9	71.9	87.3
Maharashtra	50.70	41.1	45.9	58.6	15.1	9.0	83.0	90.4
Orissa	85.80	84.9	10.9	14.6	36.1	29.2	61.4	69.6
Punjab	23.80	11.0	71.4	87.3	6.1	3.0	90.8	95.9
Rajasthan	74.60	58.0	22.2	41.0	18.6	10.2	79.2	88.7
Tamil Nadu	53.20	45.7	43.2	54.0	21.5	17.6	73.9	81.7
Uttar Pradesh	89.10	81.0	9.3	17.7	30.2	25.1	66.7	74.1
West Bengal	91.10	88.2	5.8	11.2	34.4	27.9	63.1	71.4
All-India	**69.20**	**62.4**	**27.04**	**37.1**	**22.6**	**16.5**	**74.4**	**82.8**

Sources

1. NSSO. 1990 Sarvekshana Vol. XV No.3 NSS (44th Round) 1988/89 (For 1988/89) New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.
2. NSSO. 1997 Energy used by Indian Household Report No. 410/2. New Delhi· National Sample Survey Organization, Department of Statistics, Government of India

Table 26

Households (all-India) using different fuels for cooking (%): 1991

State/union territory	*Cow dung*	*Electricity*	*Coal/coke/ lignite*	*Charcoal*	*Liquefied petroleum gas*	*Fuelwood*	*Biogas*	*Kerosene*
State								
Andhra Pradesh	2.76	0.12	0.14	0.86	7.75	80.85	0.48	5.95
Arunachal Pradesh	0.07	0.22	0.04	0.08	4.41	87.78	0.08	6.35
Assam	1.45	0.19	0.30	0.47	4.46	87.96	0.09	2.65
Bihar	35.44	0.23	9.93	0.91	1.97	44.03	0.15	0.60
Delhi	4.76	0.13	0.85	0.47	46.47	4.67	0.64	41.60
Goa	0.46	0.19	0.07	0.46	29.28	57.83	0.55	10.70
Gujarat	10.89	0.09	0.27	1.79	16.51	54.91	1.00	13.71
Haryana	26.36	0.14	0.44	0.82	12.91	52.10	0.35	5.82
Himachal Pradesh	0.14	0.48	0.07	0.60	6.37	82.30	0.44	9.28
Karnataka	1.16	1.86	0.04	0.08	6.35	78.58	1.17	9.78
Kerala	0.06	0.12	0.02	0.01	4.86	92.42	0.21	1.47
Madhya Pradesh	11.75	0.17	2.36	0.69	6.14	74.90	0.17	3.31
Maharashtra	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00
Manipur	0.28	0.18	0.08	0.44	6.66	85.50	0.39	3.26
Meghalaya	0.11	0.80	0.26	2.31	3.54	85.35	0.13	6.87
Mizoram	0.03	0.22	0.02	0.18	8.75	74.83	0.06	14.38
Nagaland	0.18	0.07	0.06	0.03	2.67	93.11	0.08	3.16
Orissa	13.50	0.68	2.41	0.57	2.27	73.47	0.26	1.77
Punjab	35.28	1.53	0.35	0.26	14.14	35.91	1.00	10.35
Rajasthan	7.61	0.06	0.25	1.14	6.23	78.09	0.17	5.62
Sikkim	0.02	0.40	0.34	0.26	2.63	74.47	0.23	21.24
Tamil Nadu	1.25	0.13	0.02	0.04	7.29	80.35	0.79	9.63
Tripura	0.46	0.07	0.02	1.54	3.35	91.52	0.09	1.92
Uttar Pradesh	0.49	1.62	0.04	0.13	8.08	77.87	0.15	9.80
West Bengal	18.04	0.21	23.57	2.12	4.87	32.13	0.22	3.69
Union territory								
Andaman and Nicobar Islands	0.06	0.07	0.06	0.01	3.97	71.47	0.51	22.66
Chandigarh	1.24	0.15	0.45	0.04	49.03	7.23	0.13	40.64
Dadra and Nagar Haveli	0.14	0.05	0.02	0.06	8.81	79.12	0.58	11.06
Daman and Diu	5.73	0.09	0.04	0.03	29.40	49.84	0.63	13.90
Lakshadweep	0.00	0.07	0.00	0.00	1.03	90.69	0.00	3.56
Pondicherry	1.48	0.08	0.05	0.04	15.26	61.24	0.83	18.44
* **India**	**15.39**	**0.31**	**3.47**	**0.77**	**7.94**	**61.50**	**0.49**	**7.16**

* excluding Jammu and Kashmir

Source

GoI. 1995 Housing and Amenities. Occasional Paper No 5 of 1994 Census of India, 1991 New Delhi Government of India

Table 27

Distribution of rural households by primary source of energy for cooking (states) (%)

	Traditional						Commercial								
	1989/90		1991		1993/94		1989/90			1991			1993/94		
State	Firewood and chips	Gobar gas/dungcake /charcoal	Fuelwood	Cowdung	Firewood and chips	Gobar gas/dungcake /charcoal	Gas (coal,oil or liquefied petroleum gas)	Kerosene	Coke and coal	Liquefied petroleum gas	Kerosene	Coal/coke/ lignite	Gas (coal,oil or liquefied petroleum gas)	Kerosene	Coke and coal
Andhra Pradesh	90.9	1.6	91.6	3.4	93.7	3.3	1.4	1.1	0.4	2.1	0.9	0.6	2.3	1.3	0.4
Assam	98.9	—	93.1	1.6	97.2	1.7	0.5	0.2	0.3	1.3	0.7	0.2	1.1	0.3	0.4
Bihar	66.4	27.0	47.4	39.5	63.4	25.9	0.2	0.2	3.8	0.2	0.1	4.5	0.3	0.2	4.1
Gujarat	84.8	6.4	75.9	14.4	78.7	12.9	1.8	4.7	0.8	3.4	3.8	0.1	4.9	6.9	0.7
Haryana	54.3	43.3	63.0	31.8	68.3	28.4	0.4	0.9	0.4	1.9	1.3	0.2	3.6	1.8	0.1
Karnataka	94.6	0.7	94.4	1.4	93.9	2.6	0.8	1.6	0.4	0.7	1.2	0.0	1.7	1.9	0.2
Kerala	94.4	0.1	96.8	0.1	92.1	4.6	1.7	1.6	0.6	1.6	0.6	0.0	4.1	1.3	0.6
Madhya Pradesh	90.1	6.8	82.9	14.6	91.1	6.9	0.5	0.7	1.5	0.5	0.5	0.6	0.5	0.3	1.4
Maharashtra	80.2	5.4	72.7	14.3	76.7	6.1	2.2	4.6	0.4	2.9	4.7	0.2	3.5	5.1	0.3
Orissa	87.4	9.1	77.1	15.2	88.9	4.5	0.1	0.3	0.4	0.4	0.3	0.6	0.3	0.4	0.5
Punjab	39.1	48.3	0.4	1.8	50.7	39.3	2.7	5.8	0.6	45.0	2.7	0.1	5.1	8.3	0.2
Rajasthan	93.6	4.2	88.0	9.1	90.0	6.5	0.1	1.5	0.4	0.5	1.0	0.1	2.0	1.4	0.7
Tamil Nadu	95.1	0.6	94.1	1.5	91.3	3.5	1.0	1.8	0.3	1.4	1.8	0.0	3.1	3.8	0.1
Uttar Pradesh	58.7	38.1	84.2	0.5	62.7	34.2	0.3	0.6	1.3	4.5	7.2	0.0	1.2	1.0	0.4
West Bengal	71.4	7.0	41.5	24.5	61.3	9.2	0.1	0.3	11.8	0.6	0.3	10.9	0.3	0.9	6.5
India	78.9	0.3	71.7	19.6	78.2	13.7	0.8	1.5	1.9	1.2	1.3	1.5	1.9	2.0	1.4

Sources

1 NSSO 1997 Energy used by Indian Households Report No 410/2 New Delhi National Sample Survey Organization, Department of Statistics, Government of India

2 NSSO 1992 Sarvekshana Vol XVI No 1 July–September 1992 Issue No 52 New Delhi National Sample Survey Organization, Department of Statistics, Government of India

3 GoI 1995 Housing and Amenities Occasional Paper No 5 of 1994 Census of India, 1991 New Delhi Government of India

Table 28

Distribution of urban household by primary source of energy for cooking (states) (%)

State	Traditional						Commercial								
	1989/90		1991		1993/94		1989/90			1991			1993/94		
	Firewood and chips	Gobar gas/dungcake /charcoal	Fuelwood	Cowdung	Firewood and chips	Gobar gas/dungcake /charcoal	Gas (coal, oil or liquefied petroleum gas)	Kerosene	Coke and coal	Liquefied petroleum gas	Kerosene	Coal/coke/ lignite	Gas (coal, oil or liquefied petroleum gas)	Kerosene	Coke and coal
Andhra Pradesh	51.9	0.9	48.0	0.9	44.1	0.6	19.4	19.7	0.9	25.19	21.53	0.36	27.90	0.21	2.40
Assam	56.6	0.2	52.1	0.4	44.1	0.4	16.6	12.8	4.7	26.65	16.71	0.77	34.50	15.50	0.70
Bihar	26.3	7.1	21.9	8.8	21.8	5.3	11.2	0.6	45.7	13.77	3.63	45.63	17.20	8.90	39.10
Gujarat	24.7	2.7	17.2	4.7	16.1	3.3	38.0	27.2	5.4	40.03	31.53	0.56	39.60	31.00	2.20
Haryana	29.3	14.5	23.4	12.1	23.8	9.5	29.5	20.6	4.6	41.95	17.77	1.20	38.60	23.00	0.70
Karnataka	55.3	0.4	43.4	0.5	36.2	0.3	14.0	19.0	1.2	18.84	28.78	0.90	26.00	26.50	0.50
Kerala	65.4	0.2	79.5	0.1	70.1	0.1	17.9	7.1	1.9	14.67	4.16	0.04	16.80	5.20	0.20
Madhya Pradesh	47.1	2.3	48.3	2.4	41.4	2.2	25.3	9.3	12.8	24.95	12.58	8.19	30.80	15.60	5.90
Maharashtra	22.6	0.6	13.7	2.4	13.8	0.7	33.9	32.5	2.9	36.99	43.99	1.27	38.80	37.60	0.50
Orissa	59.3	1.8	50.3	2.7	42.3	4.3	0.9	7.9	12.2	13.98	11.13	13.65	18.00	12.00	7.60
Punjab	18.0	13.6	15.0	10.0	14.5	6.5	27.8	34.3	2.4	41.10	27.96	1.03	40.90	35.90	0.90
Rajasthan	53.9	2.2	45.3	2.8	39.0	4.7	18.4	19.4	5.1	25.15	20.97	0.84	28.40	24.20	0.70
Tamil nadu	50.8	0.9	50.8	0.6	42.9	0.5	18.1	23.2	0.4	20.04	26.59	0.04	19.20	25.00	0.30
Uttar Pradesh	43.5	10.1	12.9	0.5	39.1	8.4	18.5	12.4	9.1	45.19	36.42	0.12	31.50	14.80	2.80
West Bengal	11.2	1.8	9.0	2.2	8.4	0.8	11.5	0.8	51.0	15.44	11.99	54.65	18.70	14.00	29.90
India	37.4	3.5	32.7	3.5	29.9	2.7	22.3	19.2	10.7	26.93	23.62	8.95	29.60	23.20	5.70

Sources

1 NSSO 1997 Energy used by Indian Households. Report No. 410/2 New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.

2 NSSO 1992 Sarvekshana Vol XVI No 1 July–September 1992 Issue No. 52 New Delhi. National Sample Survey Organization, Department of Statistics, Government of India.

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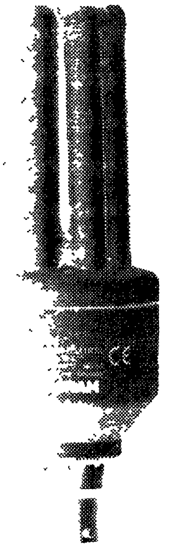

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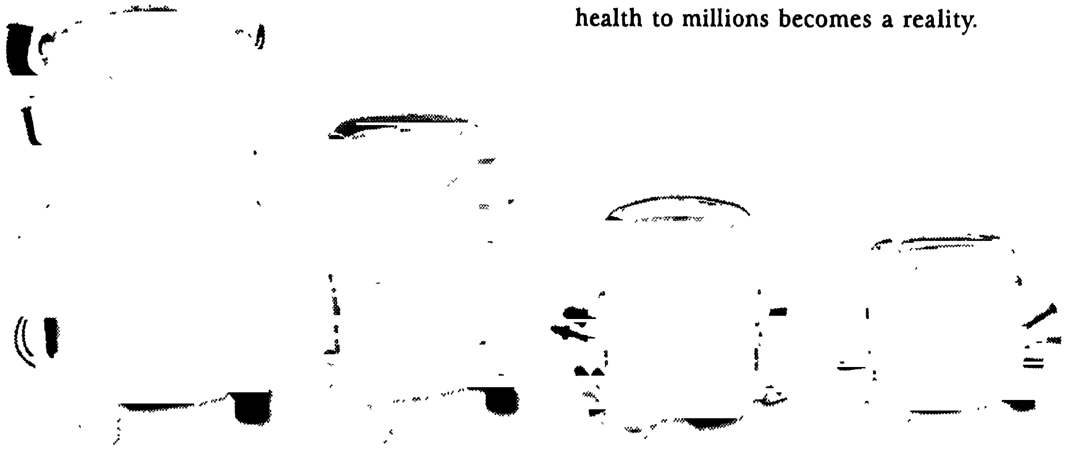

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FORESTS

Forests

Introduction

Forests regulate various ecological cycles, contribute to the state's income, and generate global impacts by influencing the environment and conserving biodiversity. They are the source of materials like fuelwood, timber, fodder, food, fibre, and medicinal herbs not only for the local population but for other segments of the society as well. Forests create considerable employment opportunities in the primary, secondary, and tertiary sectors and play a vital role in socioeconomic development.

Commercial forest products like timber and resin generate significant state revenue. The contribution of forestry and logging to the GDP (gross domestic product) was 29 300 million rupees in 1996/97 (nearly one per cent). Forests provide a habitat for a wide variety of flora and fauna to form a rich reservoir of biological diversity and genetic variability. Besides maintaining ecological security, forests play a crucial role in the conservation, enhancement, and sustenance of the global environment and act as a primary carbon sink. An alarming issue today is the considerable reduction in such services and products due to the continuous decline in forests, as the counteractive measures have yielded only limited positive impacts.

India's forests

India's total forest area, i.e., the area notified as forest, is 76.52 million hectares, which is 23.28% of the total geographical area (328.73 million hectares). Forest cover, as per the estimates of the FSI (Forests Survey of India) in 1997, is shown in Map 7 (Appendix II). Wide disparity exists on the extent of forest cover across the country. While forests in the Andaman and Nicobar Islands occupy as much as 86.9% of the total geographical area, in Haryana they occupy only 3.8%. Arunachal Pradesh, Himachal Pradesh, Manipur, Mizoram, Nagaland, and Tripura have over 50% of their land areas under forests, while Gujarat, Jammu and Kashmir, Punjab, and Rajasthan have less than 10%. The forest area in other states ranges between 10% and 50% of their land areas and the per capita forest area in India is 0.07 hectares.

The forests of India have been classified into 16 types, ranging from tropical wet evergreen to alpine, with the tropical deciduous types (both moist and dry) constituting the bulk (over 65%) (Champion and Seth 1968). Nearly eight per cent of the actual forest cover consists of tropical wet evergreen. The diversity in forest types warrants diverse management, research, development, and policies.

Out of the 76.52 million hectares of recorded forest area in 1997, about 41.65 million hectares (54.4%) constitutes reserved forests, 22.33 million hectares (29.2%) protected forests, and the remaining 12.54 million hectares (16.4%) unclassed forests. Nearly 97% of the forests are public-owned, of which 85% is administered by state governments and the remaining by corporate bodies and village communities. Privately-owned forests do not exist in any sizeable proportions.

The altitudinal distribution of the actual forest cover shows that in both the plains and the hills, it is less than the 33% (66% in the case of hilly and mountainous regions) stipulated in the National Forest Policies of 1952 and 1988. Over two-thirds of the actual forest cover are located at altitudes less than 600 m, one-fourth is located at altitudes ranging from 600 to 1800 m, and over one-twelfth at altitudes ranging from 1800 to 4000 m. The occurrence of forests is negligible at altitudes more than 4000 m, i.e., above the treeline.

Current status

India is sustaining 16.1% of the world's human population and 15.1% livestock population on

2.47% of its geographical area and just 1% of the world's forests. Nearly 70% of the population lives in rural areas and meets 62% of their domestic fuel needs by wood. A steady growth from 361 million in 1951 to 864.3 million in 1991 was observed in human population, and from 292 million in 1951 to 429.6 million in 1987 in livestock population. The human and livestock populations, which are expected to touch 1041 and 500 million, respectively, by the year 2000, have put an unprecedented stress on natural resources, especially forests and land. The demand for fuel, fodder, and timber has grown to nearly five times the sustainable supply. The biotic pressure, along with other factors, has caused changes in various strata of forests (Table I).

A number of NWFPs (non-wood forest products) are not only exported but also sustain a large number of rural, cottage, and other industries. The NWFPs provide about 40% of the total official forest revenues and 55% of forest-based employment. Nearly 500 million people living in and around forests in India rely on NWFPs as a critical component for their sustenance. The total value of NWFP exports during 1990/91 was over 16.785 billion rupees.

India's unique phytogeographical and agro-ecological diversity endows it with a wide variety of agroclimatic zones that harbour a rich repository of biological resources. With only 2.5% of the total land area of the world, the known biological diversity of India contributes 8% to the total known global biological diversity with a species count of 0.126 million. It is one of the 12 mega-biodiversity regions of the world. India has two of the 18 identified 'hot spots' (Western Ghats and Eastern Himalayas) of the world and is one of the 12 centres of origin of cultivated plants. There are about 45 000 species of plants and over 68 000 species of animals distributed in 2 biogeographical realms and 12 biogeographical provinces. Besides, there is also a sizeable endemic component. Among the flora, about 15 000 species are flowering plants, of which nearly 33% is endemic, located chiefly in 26 endemic centres. Forests are the habitat for wildlife. To conserve the same, 84 national parks and 447 wildlife sanctuaries have been created (MoEF 1998).

In India, there has been a significant decline in the quality of forests (crown density), though the area under forests has remained practically the same. The 'actual forest cover' (63.34 million hectares) constitutes 19.27% of the total geographical area of the country and 82.77% of the recorded forest area.

According to the FSI, only 36.73 million hectares (11.17% of India's total geographical area) has dense forest (crown density 40% or more), which is 1.78 million hectares less than its corresponding value in 1995; 26.13 million hectares (or 7.95%) is open forest (crown density between 10% and 40%), and nearly 482 700 hectares (0.15%) constitutes mangroves (Table I). The 1997 estimate showed a rise in all the categories except scrub forests. Though the estimate cannot be categorically compared with the earlier ones, as the methodology was being continuously upgraded, the rise in 'open' forest and 'non-forest' areas is alarming.

Points of concern

The main point of concern is the degrading 'actual forest cover'. The degradation adversely affects the supply of forest products and ecological services at micro and global levels. Also, such degradation is interlinked with degradation in several other natural resources, and may even pose a threat to human life. Forest degradation has crossed the reversible

Table I Changes in area under forests (million hectares)

Area	*1987*	*1989*	*1991*	*1993*	*1995*	*1997*
Dense forest	36.14	37.85	38.50	38.56	38.58	36.73
Open forest	27.66	25.74	25.00	25.03	24.99	26.13
Mangrove	0.40	0.42	0.42	0.42	0.45	0.48
Scrub area	7.68	6.61	5.96	5.89	6.05	5.72
Uninterpreted	1.15	0.40	1.91	0.00	0.00	0.00
Non-forest	255.74	258.78	256.93	258.82	258.71	259.67
Total	328.78	328.78	328.72	328.73	328.73	328.73

Source MoEF (1989, 1991, 1993, 1995, 1997) limits at many places and has resulted in biomass crisis, economic losses, occurrence of natural calamities, and loss of biodiversity.

Biomass crisis

Forests are being harvested for timber, industrial raw material, NWFPs, and fuelwood. The current annual withdrawal of fuelwood is estimated at 260 million cubic metres against the estimated production capacity of about 52.6 million cubic metres (about 20%) (Table II). The gap between consumption and recorded production of fuelwood seems to be widening. The gap was of the order of 207 million cubic metres in 1997 (Figure 1). The annual demand for industrial wood is about 28 million cubic metres against our production capacity of 12 million cubic metres (about 43%). Wood removed from forests is in the form of roundwood or wood in the rough as felled, which includes fuelwood and industrial roundwood. Industrial wood includes sawn wood, pulpwood, and 'others'. Both the requirement and production of industrial wood stood at 2.5 million cubic metres each in 1947. The shortfall has grown to 20 million cubic metres in 1997, meeting only 41% of the demand in that year (Table III).

Economic losses

In 1991, the production from Indian forests was estimated at 15 227 million dollars and consumption at 15 587 million dollars, outstripping production by a gap of 360 million dollars (FAO 1993). Sustainable yield from forests has been falling with degradation of forests and has resulted in a fall in industrial and fuelwood production. The estimated annual loss of industrial wood was 45 billion rupees and of fuelwood 12 billion rupees in 1997.

Table II Wood consumption (million cubic metres)

Year	Consumption	*Sustainable production*	Gap
1947	115.0	8.8	106.2
1953/54	129.4	9.7	119.7
1965/66	163.9	13.7	150.2
1975/76	199.6	28.5	171.4
1987	235.0	40.0	195.0
1994[a]	255.3	–	–
1997[b]	260.0	52.6	207.4
2010[a]	344.5	–	–

[a] Food and Agriculture Organization estimate; [b] TERI estimate
Source TERI (1998)

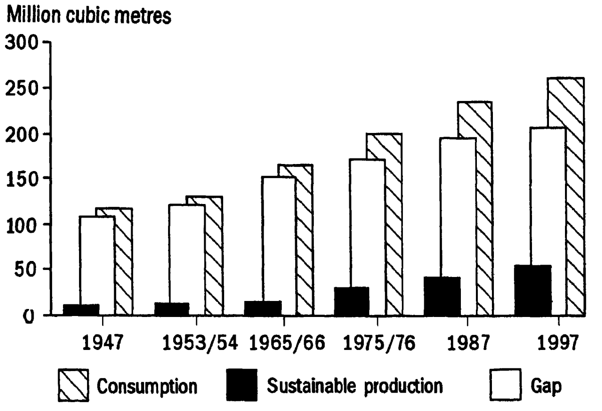

Figure 1 Fuelwood gap: 1947-97

Table III Scenario of industrial wood (million cubic metres)

Year	*Requirement*	*Production*	*Gap*	*Fraction met*
1947	2.5	2.5	0	100
1997	34.0	14.0	20	41
Rise (%)	1260.0	460.0	–	–

Source TERI (1998)

At the micro level, such degradation of forests affects the livelihood of more than 500 million people, who are engaged in the extraction of NWFPs, especially tendu leaf and fuelwood. TERI has estimated in that 1991 300 tonnes of fuelwood was being traded daily in Jabalpur, 36 tonnes in Mandla, and 22 tonnes in Dindori. Presently, the size of fuelwood market in the country, being run by un-recorded headloads, is 60 billion rupees (Sharma and Singh 1999).

Natural calamities

The role of forests in regulating global environment through carbon sequestration and reducing emissions of GHGs (greenhouse gases) has been recognized. Globally, the largest potential of reducing carbon dioxide emissions is by forests and forest plantations. Thus, indirectly, forests and plantations reduce global warming and ozone layer depletion. However, data about carbon sequestration or GHG abatement per unit of a particular type of forest or land use are yet to be generated. Landslips, flash floods, landslides, etc., are often ascribed to denudation of hills in the recent past, especially in the ecologically fragile hilly terrains.

Biodiversity losses

India is rich in biodiversity reserves and the Eastern Himalayas and Western Ghats have been identified as two of the world's 18 biodiversity hot spots. In addition, 26 endemic centres, which are home to nearly 33% of flowering plant species, have been identified. However, increasing population pressure and conflicting demands on land and forests have contributed largely to fragmentation and/or destruction of natural habitats. This has resulted in the extinction of at least 23 species. Many more species are either endangered or on the verge of extinction.

Low growing stock and productivity

The growing stock of the actual forest cover (63.34 million hectares) varies from as low as 7 m^3/ha in Punjab to as high as 244 m^3/ha in Jammu and Kashmir. The average growing stock is over 74 m^3/ha, which compares poorly with the world average of 110 m^3/ha. The total estimated growing stock of wood in the country is 4741 million cubic metres with an annual increment of 88 million cubic metres amounting to 1.86% of the total growing stock. Considering the recorded forest area of the country, the average annual production of 88 million cubic metres works out to 1.15 m^3/ha (or 1.37 m^3/ha taking into account the actual forest cover), which is much less than the world average of 2.1 m^3/ha. Thus, in terms of both growing stock and annual production, India is far behind many of the countries of the world. The potential productivity of forests of the country is, however, much higher than the actual production, and could vary from 0.41 m^3/ha in the dry forests of the Indus plains to nearly 4 m^3/ha in the western coast and the Andaman and Nicobar Islands. The low and declining productivity may be ascribed largely to biotic pressure for various types of needs. The forests today are subjected to at least five times more pressure than what they can withstand.

Regeneration failure

Excessive grazing, frequent fires, and other biotic factors have adversely affected the natural regeneration of our forests. Nearly 73.6% of the forest area does not have regeneration of important species, and forest area with no regeneration varies from 15% in West Bengal to 90 in Jammu and Kashmir. These are indicators of a deteriorating situation leading to progressive degradation of forests.

The pressures of increasing livestock population and migratory grazers are other forces responsible for the continual degradation of forests, grasslands, and alpine pastures causing widespread devastation. It is estimated that currently over 100 million heads of livestock or 110 million cow units graze in the forests of the country. Considering the degraded state of the forests and a minimum requirement of 2 ha of land for one cow unit, the grazing pressure on the forests is more than three times the carrying capacity of this resource.

Diversion of forest area, encroachment, and shifting cultivation

The forest area lost due to various reasons during the period 1952–80 is inferred to be nearly 4.33 million hectares with an average loss of 155 000 hectares annually. The impact of diversion to the agriculture on the denudation of forests has been the maximum, and the forest area lost due to diversion during this period is estimated at 2.62million hectares. However, upon the enactment of the Forest Conservation Act in 1980, the forest area diverted for non-forest uses between end-1980 and mid-1993 was only 304 000 hectares, reducing the rate of diversion to approximately 25 000 hectares a year. In the first 50 years of independence, 5.3 million hectares of forest land (about seven per cent of total forest area) is estimated to have been diverted to other uses (agriculture, river valley projects, mining, industries, townships, roads, transmission lines, etc.), of which agriculture alone accounts for 60% of the area diverted. Moreover, nearly 700 000 hectares of forest land was encroached upon between 1951 and 1982.

Shifting cultivation (*jhumming*) – a low-energy budget and a low-investment system of subsistence husbandry – is practised in about 16 states of India, and is most prevalent in the seven north-eastern states and Orissa. Since there is not enough area for the system to function, forest degradation is rampant. Some recent surveys estimated that the total area affected by this practice was over 7.7 million hectares between 1991 and 1993.

Forest fires

Forest fire is one of the most dangerous causes of damage to forests and wildlife. On an average, 53.1% of the forest area is affected by fire and it ranges from as low as 6.8% to as high as 97%. About 8.92% of the forest area is affected by frequent fires and 44.25% by occasional fires. Information collected by the FSI indicates that 51% of the area in Assam and Gujarat, 67% in Bihar, 69% in Himachal Pradesh, 46% in Jammu and Kashmir, 45% in Karnataka, 76% in Madhya Pradesh, 99.6% in Manipur, 94% in Meghalaya, 87% in Nagaland, 94% in Orissa, 37% in Sikkim, 58% in Uttar Pradesh, and 33% in West Bengal get affected by ground fires every year.

Important initiatives

Wastelands in the country are estimated at 175 million hectares as per a high-level committee of the Government of India. These are mostly degraded lands, which can be brought under some kind of vegetative cover with reasonable effort and which are currently underutilized, and lands which are deteriorating due to inappropriate water and soil management or on account of natural causes. To revegetate the land, the National Wasteland Development Board was established in 1984, which now operates under the control of the MoRD (Ministry of Rural Development). The NAEB (National Afforestation and Eco-development Board) is operating under the MoEF on the same line and helps in ameliorating wasted lands and combating desertification. Besides government departments, the boards involve NGOs (non-governmental organizations), eco-task forces, and forest dwellers.

Although the pressure on forests continues unabated, various forestry development programmes and regulatory mechanisms have stabilized the forest cover to around 19.4% of the total in this decade by arresting the overall trend of deforestation. However, about 30.8 million hectares of forests is still in the open category and degraded. Of late, several major initiatives have been taken by the Government of India for the management of forest resources on a sustainable basis and to increase the forest cover and its productivity. Some of the important efforts taken in this direction are listed below.

- The enactment of the Forest Conservation Act, the Wildlife Protection Act, and the Environment (Protection) Act
- The inclusion of the subject (wasteland development) in the Concurrent List of the Constitution
- The launching of massive afforestation programmes including social, farm and agro-forestry, and wasteland development
- The promotion of wood substitution
- The adoption of the National Forest Policy (1988)
- The involvement of local communities in the protection, management, and development of forests (PFM [participatory forest management])
- The enlargement of the network of 'protected areas'
- The drawing up of a National Wildlife Action Plan and implementation of several wildlife projects for the protection of species and ecosystems
- The regulation of wildlife trade and commerce

An amount of 12 000 million rupees was allocated to the MoEF during the Eighth Five-Year Plan. The budgetary allocation to forestry and wildlife observed an increase from 5437 million rupees in 1997/98 to 6540.9 million rupees in 1998/99. Furthermore, the allocation to forestry and wildlife as a proportion of the total budget earmarked for the MoEF was 26% (1735.3 million rupees). The National River Conservation Directorate and the NAEB have been allotted 1917 million rupees and 920 million rupees, respectively.

Generally, production techniques are adopted to improve the stock of degraded or denuded forests. With PFM (or JFM [joint forest management]) being adopted, protection techniques are successfully implemented. In JFM areas of Haryana, the yield of fodder grass and commercial grass have increased by 25 and 35 times, respectively, in 20 years (Dhar 1994). Recently, the need for improving planting stock has grown popular. Techniques like clonal plantations and the introduction of superior clones are being adopted on a large scale. Various NGOs and corporate organizations have ventured into the field and are developing their own clones. Efforts are being directed to reduce the rotation age and increase productivity.

The goal of the National Forest Policy (1988) is to have a minimum of one-third of the total land area of the country under forests. The policy aims at creating a mass movement of the people with active involvement of women for achieving the desired objectives and to minimize pressure on the existing forests. The policy lays emphasis on meeting the local needs, particularly of the tribals and the rural poor.

In a major shift from the traditional systems of forest management, the MoEF issued policy instructions consistent with the revised National Forest Policy (1988) to all state governments on 1 June 1990, supporting the involvement of village communities and NGOs in the regeneration, management, and protection of degraded forests. The implications of this document are far-reaching and assertive in support of the PFM strategy. The state governments of Haryana and West Bengal were pioneers in adopting the PFM approach and, in the last decade, 22 state governments have also adopted this approach by issuing enabling orders/resolutions. The basic philosophy underlying the proposed policy is to link the economic interests of the rural poor living in and around forests with sustainable management of these resources and environmental security. While the state forest departments are gaining experience on the operational needs for this approach to forest management, it is rather too early to judge the success of this programme though ground realities in some states hold promise. In the areas of success stories, people are helping fight fires, control grazing, and check forest offences. Already 35 000 villages in 22 states are helping conserve about 7 million hectares of forest (almost 11% of total forest area). The Planning Commission also recommended similar collaborations in the Ninth Five-Year Plan (Box 1).

Box 1 Some of the recommendations of the Ninth Five-Year Plan (1997-2001)

- People's (particularly women) participation in the management and sharing of usufruct through joint forest management.
- Empowering people through information generation, dissemination, and access.
- Involvement of NGOs for awareness building and as an interface between the forest department and the people would be encouraged.
- Integrated development of villages in and around forests.
- Inter-sectoral coordination and cooperation.
- Ensuring technical and scientific inputs.
- Evolving rights for common property resources.
- Integrating environment with decision-making through valuation of environmental impacts; evolving market-based economic instruments as an alternative to the command and control form of environmental regulation; appropriate fiscal reforms; and natural resource accounting.
- Private sector participation to be encouraged for afforesting degraded and denuded lands.
- Area-specific programmes like river conservation, lake conservation, and Taj Trapezium conservation shall be launched and monitored promptly.
- Assistance will be provided to botanical gardens and biodiversity conservation activities will be intensified by seeking cooperation from various stakeholder agencies and communities.

Efforts to bring areas such as social forestry and agro-forestry under plantation were always given high priority. The Government of India launched large schemes on social forestry and later on agro-forestry in 1970s. A large number of seedlings were planted on roadsides, canal sides, village common lands, and private lands. In order to cope with the rising demand for wood and to rehabilitate degraded and denuded lands, plantations have so far (up to 1992/93) been raised over an area of nearly 19.86 million hectares. Besides, 3852.73 million seedlings have been planted on private lands under different programmes of afforestation. The development of wastelands has been identified as an important area where a concerted effort from the concerned ministries and agencies and organizations involved with people's participation is called for. Large-scale afforestation with suitable species along with identified inputs may help to ameliorate most of the wastelands and, in the process, improve the forest cover of the country.

Through organizations like the Botanical Survey of India, the Zoological Survey of India, the Central Zone Authority, and state forest departments, explorations and census are conducted to identify changes in populations so that suitable interventions may be employed for endangered species. To ensure conservation of 9 biosphere reserves, 84 national parks and 447 wildlife sanctuaries have been established. In 1997/98, 135.5 million rupees was provided only for Project Tiger areas. Most importantly, a draft outline of legislation on biodiversity was released during the same year.

The National Forestry Action Programme envisages the preparation of an action plan for the forestry sector with long-, medium-, and short-term perspectives. The programme also seeks to identify and quantify investment and technical assistance requirements in line with the National Forest Policy (1988) and its proper implementation. The priority areas of actions identified are listed below.

- Protecting existing resources
- Increasing forest productivity
- Reducing total demand
- Strengthening policy and the institutional framework
- Expanding forest area
- Working out management strategies
- Laying down the investment priorities

In January 1994, the MoEF issued an EAP (Environment Action Programme). The priority areas identified by the EAP include afforestation, wasteland development, conservation of soil and moisture, and prevention of ground and surface water pollution. The EAP recognizes that the improper use of land resources has created serious ecological and socio-economic problems. The growing demand for fuelwood, fodder, and food has depleted or eliminated protective vegetative cover in many areas.

The Forest Policy made in 1894 aimed at better and scientific governance of the forests; the Forest Policy of 1952 aimed at evolving more systems for forest product utilization and satisfying demands of various end-users. The Forest Policy devised in 1988 laid stress on forest conservation, maintenance of ecological stability, and enhanced role for people, especially forest dwellers. The policies were supported by various forest acts.

The Indian Forest Act (1927) consolidates the law relating to forests. The Protection Act (1972) provides the protection of wildlife and birds. The Forest (Conservation) Act (1980) aims at providing conservation of forests. In the last two decades, conservation of forests has emerged as the keyword and people's participation is being sought. Different state forest departments have issued various legislations, orders, etc., to promote the PFM, conserve wildlife, restrict felling, etc. So far 22 states have issued resolutions to adopt the JFM policy. The Uttar Pradesh government's ban on fellings above 1000/m high altitude and the Supreme Court's ban on green fellings have been instrumental in checking rampant fellings and ecological degradation.

Systematic documentation of scientific observations made by various forest officers in nurseries and plantations marked the beginning of forestry research. To continue as well as consolidate over the work done and develop cadres of forestry-oriented workers, the ICFRE (Indian Council of Forestry Research and Education) was instituted in Dehra Dun in 1986. The ICFRE runs the 11 research institutes listed below.

1. Forest Research Institute (Dehra Dun)
2. Institute of Forest Genetics and Tree Breeding (Coimbatore)
3. Institute of Wood Science and Technology (Bangalore)
4. Arid Forestry Research Institute (Jodhpur)
5. Institue of Rain and Moist Deciduous Forest Research (Jorhart)
6. Himalyan Forest Research Institute (Shimla)
7. Centre for Forest Productivity (Ranchi)
8. Centre for Social Forest and Eco-Rehabilitation (Allahabad)
9. Tropical Forest Research Institute (Jabalpur)
10. Forestry Research Centre (Hyderabad)
11. Centre for Forestry Research and Human Resource Development (Chhindwara)

Besides the ICFRE institutes, there are five state-run forest research institutes in (1) Peechi (Kerala), (2) Jabalpur (Madhya Pradesh), (3) Kanpur (Uttar Pradesh), (4) Srinagar (Jammu and Kashmir), and (5) Itanagar (Arunachal Pradesh). They also conduct research on forestry issues. Various ICAR (Indian Council of Agricultural Research) institutes also conduct similar research. About 14 ICAR universities started undergraduate degree courses in forestry and later a few of them started imparting post-graduate and doctoral level education. In the 1980s and the 1990s, a few corporate houses and NGOs started research and training in forestry. These include the ITC Bhadrachalam Paper Boards (Andhra Pradesh), the WIMCO (Western India Matches Company) Seedling (Uttar Pradesh), the Kitply Plywoods (Madhya Pradesh), the Tata Tea (Kerala), and TERI (New Delhi). Besides, autonomus research organizations like the Wildlife Institute of India (Dehra Dun), the Indian Plywood Industries Research and Training Institute (Bangalore), the G B Pant Institute of Himalayan Environment and Development (Almora), and the ICAR institutes like the Central Arid Zone Research Institute are also taking up R&D activities in the forestry sector.

For further extension of information on forests and biodiversity, 4700 eco-clubs were funded; 144

district-level *Paryavaran Vahini* (task force on environment) were constituted; two environmental information service centres were established, and a quarterly newsletter titled *Enviro News* was published in 1997/98. The sources provide information about various policies, programmes, rules, and regulation adopted by the MoEF. Various universities, research centres, and professional bodies also disseminate information among villagers, professionals, and researchers through events and publications.

There have been concrete achievements during the Eighth Five-Year Plan in terms of area coverage under special purpose plantations. A number of centre- and state-sponsored schemes were launched in 13 states to control fires, encourage afforestation on degraded forests (783 303 hectares planted), reclamation of wastelands, promote aerial seeding, and increase the area under the JFM programme. Most of the schemes were initiated earlier and were continued during the Seventh and Eighth Five-Year Plans. Now, the schemes shall be further intensified by laying more emphasis on people's participation through JFM and adopting integrated wasteland development approach based on village/micro-watershed plans. The current plan aims at ensuring environmental sustainability of the development process through social mobilization and participation of people at all levels.

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New Delhi: Tata Energy Research Institute. 346 pp.

Table 1

Contribution (million rupees) of forestry and logging to the GDP (gross domestic product) and its percentage share: 1980/81 to 1996/97

Year	Contribution to GDP by forestry and logging		All-India GDP		Percentage share of forestry and logging in total GDP	
	Current prices	Constant (1980/81) prices	Current prices	Constant (1980/81) prices	Current prices	Constant (1980/81) prices
1980/81	32620	32620	1224270	1224270	2.66	2.66
1981/82	39410	33250	1432160	1298890	2 75	2.56
1982/83	44500	32970	1593950	1339150	2.79	2.46
1983/84	47320	31990	1867230	1448650	2.53	2 21
1984/85	50530	31800	2085330	1504330	2.42	2.11
1985/86	52860	31810	2337990	1565660	2.26	2.03
1986/87	57580	30900	2600300	1632710	2.21	1.89
1987/88	61780	29860	2947650	1703220	2.10	1.75
1988/89	68280	29400	3527060	1884610	1.94	1.56
1989/90	78230	31950	4086620	2014530	1.64	1.59
1990/91	82810	31050	4777970	2122760	1.73	1 46
1991/92	83900	30830	5520300	2141560	1.52	1.44
1992/93	86690	30950	6276340	2234380	1.38	1.39
1993/94	92500	28870	7231030	2360640	1.28	1.22
1994/95	102610	28650	8583400	2560950	1.20	1.12
1995/96	112670	29250	1006286	2761320	1.12	1.06
1996/97	112930	29300	11492150	2968450	0.98	0.99

provisional
quick estimates

Sources

1 MoPPI 1996 National Accounts Statistics pp. 168–169 New Delhi: Central Statistical Organization, Department of Statistics, Ministry of Planning and Programme Implementation 247 pp.

2 CSO 1997 CSO's press note on quick estimates of national income consumption, expenditure, saving and capital formation, 1996/97 New Delhi Central Statistical Organization (For 1995/96 and 1996/97)

For more details, please see TEDDY ONLINE+ [Section: Forest (macro and state level data)]

Table 2

Value of output (million rupees) from forestry and logging. 1980/81 to 1994/95

Year	Current prices				Constant (1980/81) prices			
	Industrial wood	Firewood	Minor forest products	**Total**	Industrial wood	Firewood	Minor forest products	**Total**
1980/81	9130	23090	4030	**36250**	9130	23090	4030	**36250**
1984/85	13150	35890	7110	**56150**	7270	23180	4880	**35330**
1985/86	14550	36560	7620	**58730**	7280	23240	4820	**35340**
1986/87	14650	41660	7670	**63980**	6580	23290	4460	**34330**
1987/88	14000	46890	7760	**68650**	5810	23360	4010	**33180**
1988/89	13860	51500	10510	**75870**	5020	23480	4120	**32620**
1989/90	15610	54770	16540	**86920**	5190	23490	6820	**35500**
1990/91	14700	59910	17400	**92010**	4610	23500	6390	**34500**
1991/92	15880	62490	14850	**92340**	4340	23520	6400	**34260**
1992/93	15100	67950	15330	**98380**	3940	23540	5300	**32780**
1993/94	18160	76390	14740	**109290**	3930	23580	4500	**32010**
1994/95	18080	79900	15030	**114010**	3950	23610	4270	**31830**

Source

MoPPI 1997 National Accounts Statistics pp 202–203 New Delhi: Central Statistical Organization, Department of Statistics, Ministry of Planning and Programme Implementation 247 pp

For more details, please see TEDDY ONLINE+ [Section: Forest (macro and state-level data)]

Table 3

Land cover as per 1987, 1995, and 1997 assessments in India

Category	*Area (km²) 1987*	*Percentage of the total geographical area 1987*	*Area (km²) 1995*	*Percentage of the total geographical area 1995*	*Area (km²) 1997*	*Percentage of the total geographical area 1997*
Forest cover						
Dense forest (crown density 40% and above)	361412	10.99	385037	11.7	367260	11.2
Open forest (crown density 10% to less than 40%)	276583	8.41	249309	7.6	261310	8.0
Mangroves	4046	0.12	4533	0.1	4827	0.2
Scrub area (tree lands with less than 10% crown density)	76796	2.34	60528	1.8	57211	1.7
Non-forest	2557436	77.79	2587856	78.7	2596655	79.0
Uninterpreted	-11524	—	—	—	—	—
Grand total	**3287797**	**100**	**3287263**	**100.0**	**3287263**	**100.0**

Sources

1 MoEF 1989 The State of Forest Report. Dehra Dun. Forest Survey of India Ministry of Environment and Forests 50. pp

2 MoEF. 1995 The State of Forest Report p 7 Dehra Dun. Forest Survey of India Ministry of Environment and Forests 98 pp.

3. MoEF 1997. The State of Forest Report. p. 5 Dehra Dun Forest Survey of India Ministry of Environment and Forests 72 pp

For more details, please see TEDDY ONLINE+ [Section. Forest (forest cover)]

Table 4

Classification of total forest area (km²): 1970/71 to 1997

Classes	*1970/71*	*1975/76*	*1979/80 **	*1985/86 ‡*	*1991*	*1995*	*1997*
Total forest area	**738444 §**	**747350 †**	**729077 †**	**718022**	**770078**	**765210**	**765210**
Area by legal status							
Reserved	360247	389690	372523	406115	414916	416516	416516
Protected	212739	231890	225364	215085	233080	223309	223309
Unclassed	115139	125770	105579	120484	122081	125385	125385

* provisional

† includes 8566 km² for want of legal classification

‡ also includes forest area not accounted for due to lack of details

§ includes 10 580 km² area outside the forest department

Sources

1. CSO Statistical Abstracts (various issues) New Delhi Central Statistical Organization

2. MoEF 1997 The State of Forest Report p. 12 Dehra Dun Forest Survey of India. Ministry of Environment and Forests 72 pp

Table 5

Status of forest cover in various states/union territories of India (km²): 1997 assessment

State/union territory	GA	RFC	Percentage of RFC to GA	AFC	Percentage of AFC to GA	Percentage of AFC to RFC	Reserved forest	Protected forest	Unclassed forest
State									
Andhra Pradesh	275068	63814	23.20	43290	15.70	67.84	50479	12365	970
Arunachal Pradesh	83743	51540	61.54	68602	81.90	133.10	15321	8	36211
Assam	78438	30708	39.15	23824	30.40	77.58	18242	3934	8532
Bihar	173877	29226	16.81	26524	15.30	90.75	5051	24168	7
Delhi	1483	42	2.83	26	1.70	61.90	42	—	—
Goa, Daman, and Diu	3814	1424	38.46	1255	36.50	88.13	165	—	1259
Gujarat	196024	19393	9.89	12578	6.40	64.86	13819	997	4577
Haryana	44212	1673	3.78	604	1.40	36.10	247	1104	322
Himachal Pradesh	55673	35407	63.69	12521	22.50	35.36	1896	31473	2038
Jammu and Kashmir	222235	20182	9.08	20440	9.20	101.28	20182	—	—
Karnataka	191791	38724	20.19	32403	16.90	83.68	28611	3932	6181
Kerala	38863	11221	28.87	10334	26.60	92.10	11038	183	—
Madhya Pradesh	443446	154497	34.84	131195	29.60	84.92	82700	66678	5119
Maharashtra	307690	63842	20.75	46143	15.00	72.28	48373	9350	6119
Manipur	22327	15154	67.87	17418	78.00	114.94	1463	4171	9520
Meghalaya	22429	9496	42.34	15657	69.80	164.88	981	12	8503
Mizoram	21081	15935	75.59	18775	89.10	117.82	7127	3568	5240
Nagaland	16579	8629	52.04	14221	85.80	164.80	86	507	8036
Orissa	155707	57184	36.73	46941	30.10	82.09	27087	30080	17
Punjab	50362	2901	5.76	1387	2.80	47.81	44	1107	1750
Rajasthan	342239	31700	9.26	13353	3.90	42.12	11585	16837	3278
Sikkim	7096	2650	37.34	3129	44.10	118.08	2261	285	104
Tamil Nadu	130058	22628	17.40	17064	13.10	75.41	19486	2528	614
Tripura	10486	6292	60.01	5546	52.90	88.14	3588	509	2196
Uttar Pradesh	294411	51663	17.54	33994	11.50	65.80	36425	1499	13739
West Bengal	88752	11879	13.38	8349	9.40	70.28	7054	3772	1053
Union territory									
Andaman and Nicobar Islands	8249	7171	86.93	7613	92.30	106.16	2929	4242	—
Chandigarh	114	31	27.19	7	6.10	22.58	31	—	—
Dadra and Nagar Haveli	491	203	41.34	204	41.50	100.49	203	—	—
Lakshadweep	32	—	—	—	—	—	—	—	—
Pondicherry	493	—	—	—	—	—	—	—	—
Total	**3287263**	**765210**	**23.28**	**633397**	**19.27**	**82.77**	**416516**	**223309**	**125385**

GA: geographical area, RFC: recorded forest cover, AFC: actual forest cover

Source

MoEF. 1997 The State of Forest Report. pp 11–12. Dehra Dun Forest Survey of India. Ministry of Environment and Forests. 72. pp.

For more details, please see TEDDY ONLINE+ [Section: Forest (forest cover)]

Table 6

Comparison of forest cover (km²): 1989, 1995, and 1997 assessments

State/union territory	*1989*	*1995*	*1997*	*Change in forest cover (1989–97)*	*Change in forest cover (1995–97)*
State					
Andhra Pradesh	47911	47112	43290	–4621	–3822
Arunachal Pradesh	68763	68621	68602	–161	–19
Assam	26058	24061	23824	–2234	–237
Bihar	26934	26561	26524	–410	–37
Goa, Daman, and Diu	1302	1250	1255	–47	5
Gujarat	11670	12320	12578	908	258
Haryana	563	603	604	41	1
Himachal Pradesh	13377	12501	12521	–856	20
Jammu and Kashmir	20424	20433	20440	16	7
Karnataka	32100	32382	32403	303	21
Kerala	10149	10336	10334	185	–02
Madhya Pradesh	133191	135164	131195	–1996	–3969
Maharashtra	44058	43843	46143	2085	2300
Manipur	17885	17558	17418	–467	–140
Meghalaya	15690	15714	15657	–33	–57
Mizoram	18178	18576	18775	597	199
Nagaland	14356	14291	14221	–135	–70
Orissa	47137	47107	46941	–196	–166
Punjab	1161	1342	1387	226	45
Rajasthan	12966	13280	13353	387	73
Sikkim	3124	3127	3129	5	2
Tamil Nadu	17715	17045 †	17064	–651	19
Tripura	5325	5538	5546	221	8
Uttar Pradesh	33844	33986	33994	150	8
West Bengal	8394	8276	8349	–45	73
Union territory					
Andaman and Nicobar Islands	7624	7615	7613	–11	–02
Chandigarh	8	7	7	–1	—
Dadra and Nagar Haveli	205	204	204	–1	—
Delhi	22	26	26	4	—
Lakshadweep*	—	—	—	—	—
Pondicherry*	—	—	—	—	—
Total	**640134**	**638879**	**633397**	**–6737**	**–5482**

no discernible forest cover

an area of 721 km² of tea gardens earlier shown as forest cover has been excluded from the forest cover

Sources

1. MoEF. 1989. The State of Forest Report. p. 25. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests. 50. pp
2. MoEF. 1995. The State of Forest Report. p. 19. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests. 98. pp
3. MoEF. 1997. The State of Forest Report p. 8. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests 72. pp.

For more details, please see TEDDY ONLINE+ [Section: Forest (forest cover)]

Table 7

Extent of dense forest, open forest, and mangroves (km^2): 1997 assessment

State/union territory	*Dense forest*	*Open forest*	*Mangroves*	*Scrub*	*Non-forest*	***Total***
State						
Andhra Pradesh	23048	19859	383	11191	220587	**43290**
Arunachal Pradesh	54155	14447	—	415	14726	**68602**
Assam	15548	8276	—	635	53979	**23824**
Bihar	13300	13224	—	1916	145437	**26524**
Delhi	16	10		2	1455	**26**
Goa	995	252	5	16	2434	**1252**
Gujarat	6337	5250	991	2780	180666	**12578**
Haryana	370	234	—	157	43451	**604**
Himachal Pradesh	9560	2961	—	1825	41327	**12521**
Jammu and Kashmir	11020	9420	—	3088	198707	**20440**
Karnataka	24854	7546	3	4566	154822	**32403**
Kerala	8454	1880	—	83	28446	**10334**
Madhya Pradesh	82745	48450	—	3320	308931	**131195**
Maharashtra	23622	22397	124	7380	254167	**46143**
Manipur	4937	12481	—	911	3998	**17418**
Meghalaya	4044	11613	—	849	5923	**15657**
Mizoram	4348	14427	—	937	1369	**18775**
Nagaland	3487	10734	—	70	2288	**14221**
Orissa	26101	20629	211	5461	103305	**46941**
Punjab	511	876	—	116	48859	**1387**
Rajasthan	3690	9663	—	6781	322105	**13353**
Sikkim	2423	706	—	439	3528	**3129**
Tamil Nadu	8676	8367	21	2832	110162	**17064**
Tripura	1819	3727	—	150	4790	**5546**
Uttar Pradesh	22958	11036	—	1170	259247	**33994**
West Bengal	3557	2669	2123	109	80294	**8349**
Union territory						
Andaman and Nicobar Islands	6520	127	966	—	636	**7613**
Chandigarh	6	1	—	—	107	**7**
Dadra and Nagar Haveli	159	45	—	12	275	**204**
Daman and Diu	—	3	—	—	109	**3**
Lakshadweep	—	—	—	—	32	**0**
Pondicherry	—	—	—	—	493	**0**
Total	**367260**	**261310**	**4827**	**57211**	**2596655**	**633397**

no discernible forest cover

Sources

1. MoEF. 1993. The State of Forest Report. p. 25. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests.
2. MoEF. 1995. The State of Forest Report. p. 24 Dehra Dun. Forest Survey of India. Ministry of Environment and Forests. 98. pp.
3. MoEF. 1997. The State of Forest Report. p. 6–7. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests. 72. pp.

For more details, please see TEDDY ONLINE+ [Section: Forest (forest cover)]

Table 8

Estimate of wastelands (million hectares) in India

State/union territory	*Saline and alkaline lands*	*Wind eroded area*	*Water eroded area*	*Non-forest degraded area*	*Forest degraded area*	***Total***
State						
Andhra Pradesh	0.0240	—	0.7442	0.7682	0.3734	**1.1416**
Assam	—	—	0.0935	0.0935	0.0795	**0.1730**
Bihar	0.0004	—	0.3892	0 3896	0.1562	**0.5458**
Gujarat	0.1214	0.0704	0.5235	0.7153	0.0683	**0.7836**
Haryana	0.0526	0.1599	0.0276	0.2404	0.0074	**0.2478**
Himachal Pradesh	—	—	0.1424	0.1424	0.0534	**0.1958**
Jammu and Kashmir	—	—	0.0531	0.0531	0.1034	**0.1565**
Karnataka	0.0404	—	0.6718	0.7122	0.2043	**0.9165**
Kerala	0.0016	—	0.1037	0 1053	0.0226	**0.1279**
Madhya Pradesh	0.0242	—	1.2705	1 2947	0.7195	**2.0142**
Maharashtra	0.0534	—	1.1026	1 1560	0 2841	**1.4401**
Manipur	—	—	0.0014	0.0014	0 1424	**0.1438**
Meghalaya	—	—	0.0815	0 0815	0.1103	**0.1918**
Nagaland	—	—	0.0508	0 0508	0.0878	**0.1386**
Orissa	0.0404	—	0.2753	0 3157	0 3227	**0.6384**
Punjab	0.0688	—	0.0463	0 1151	0 0079	**0.1230**
Rajasthan	0.0728	1 0623	0.6659	1.8010	0.1933	**1.9934**
Sikkim	—	—	0 0131	0 0131	0 0150	**0.0281**
Tamil Nadu	0.0004	—	0 3388	0.3392	0.1009	**0.4401**
Tripura	—	—	0.0108	0 0108	0.0865	**0.0973**
Uttar Pradesh	0.1295	—	0.5340	0 6635	0.1426	**0.8061**
West Bengal	0.0850	—	0.1327	0 2177	0 0359	**0.2536**
Union territories	0.0016	—	0.0873	0 0889	0.2715	**0.3604**
Total	**0.7165**	**1.2926**	**7.3600**	**9.3691**	**3.5889**	**12.9580**

Source

MoEF. 1985–89 Developing India's Wastelands New Delhi· National Wastelands Development Board, Ministry of Environment and Forests

Table 9

National parks, wildlife sanctuaries in India: 1995

State/union territory	*National parks*		*Wildlife sanctuaries*	
	Number	*Area (km²)*	*Number*	*Area (km²)*
State				
Andhra Pradesh	1	352.62	20	12084.59
Arunachal Pradesh	2	2468.23	9	6777.75
Assam	2	930.00	9	1381.58
Bihar	2	567.32	19	4624.30
Delhi	—	—	1	13.20
Goa	1	107.00	4	335.43
Gujarat	4	479.67	21	16744.27
Haryana	1	1.43	9	229.18
Himachal Pradesh	2	1295.00	29	4576.92
Jammu and Kashmir	4	3810.07	16	10163.67
Karnataka	5	2472.18	20	4229.21
Kerala	3	536.52	12	1810.36
Madhya Pradesh	11	6143.12	32	10847.29
Maharashtra	5	956.45	24	14309.51
Manipur	2	81.80	1	184.85
Meghalaya	2	386.70	3	34.21
Mizoram	2	250.00	3	720.00
Nagaland	1	202.02	3	34.35
Orissa	2	1212.70	17	6175.49
Punjab	—	—	6	294.82
Rajasthan	4	3856.53	22	5694.02
Sikkim	1	850.00	4	161.10
Tamil Nadu	5	307.86	13	2527.29
Tripura	—	—	4	603.62
Uttar Pradesh	7	5409.05	28	8078.52
West Bengal	5	1692.65	16	1064.29
Union territory				
Andaman and Nicobar Islands	6	315.61	94	437.16
Chandigarh	—	—	1	25.42
Dadra and Nagar Haveli	—	—	—	—
Daman and Diu	—	—	1	2.18
Lakshadweep	—	—	—	—
Pondicherry	—	—	—	—
Total	**80**	**34684.53**	**441**	**114164.50**

Source

MoEF. 1995. The State of Forest Report. p. 94. Dehra Dun: Forest Survey of India, Ministry of Environment and Forests. 98. pp.

For more details, please see TEDDY ONLINE+ [Section: Forest (national parks)]

Table 10

Major produce (thousand cubic metres) from forests: 1970/71 to 1993/94

Wood	*1970/71*	*1975/76*	*1976/77* *	*1977/78* *	*1978/79* *	*1979/80* *	*1984/85* £	*1990/91*	*1991/92*	*1992/93*	*1993/94*
† Timber	—	—	—	—	—	—	6439	2871.22	3152.19	3238.56	21055.12
‡ Pulp and match-wood	9655	10772	8185	8303	7966	7561	—	—	—	—	—
§ Firewood	12090	15122	12412	14702	14304	13920	11104	2197.22	1128.57	1520.09	2681.95
Total	**21745**	**25894**	**20597**	**23005**	**22270**	**21481**	**17543**	**5068.44**	**4280.76**	**4758.65**	**23737.07**

* provisional
£ firewood includes charcoal and pulp wood
† included in pulp and match-wood from 1970/71 to 1979/80
‡ includes data on roundwood
§ includes charcoal wood

Sources

1. MoEF. India's Forests (various issues). New Delhi. Survey and Utilization Division, Ministry of Environment and Forests.
2. MoPPI. 1998. Statistical Abstracts of India. 1997. New Delhi: Ministry of Planning and Program Implementation, Government of India.

Table 11

Plan outlays (million rupees) on forestry and wildlife during different plan periods

State/union territory	*Sixth Plan (1980–85)*	*Seventh Plan (1985–90)*	*Eighth Plan (1992–97)*	*Annual Plans*						
				1990/91	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
State										
Andhra Pradesh	105.0	657.0	684.2	140.0	80.6	50.0	75.0	160.0	160.0	116.0
Arunachal Pradesh	95.2	300.0	473.4	71.0	95.0	100.0	110.0	120.0	137.6	142.5
Assam	252.0	700.0	1169.8	222.4	230.8	258.4	258.4	258.4	289.0	260.5
Bihar	180.0	450.0	1906.0	250.0	315.0	310.4	326.4	326.4	326.4	143.5
Goa	45.0	60.0	1130.0	16.2	11.6	20.6	21.7	21.7	23.3	23.3
Gujarat	890.0	1296.4	3095.0	380.5	520.0	530.0	530.0	551.7	640.7	1248.2
Haryana	145.0	670.0	1237.0	255.0	231.5	311.4	344.9	309.0	374.7	339.8
Himachal Pradesh	290.0	1168.4	2118.5	267.0	326.0	409.0	455.0	416.9	469.9	518.0
Jammu and Kashmir	102.8	349.2	1076.0	149.0	148.9	154.8	191.9	189.6	218.1	275.6
Karnataka	307.5	620.0	2097.6	187.8	440.3	347.1	542.0	566.8	605.1	632.6
Kerala	186.2	700.0	980.5	184.0	285.0	248.5	175.0	235.0	260.0	273.5
Madhya Pradesh	380.0	787.7	2125.8	410.0	493.9	503.9	503.9	509.0	766.5	936.6
Maharashtra	487.5	1060.0	5046.4	370.8	437.8	441.4	771.4	111.1	1262.5	1433.9
Manipur	47.5	144.1	240.0	52.0	52.0	52.0	56.0	49.0	58.8	53.0
Meghalaya	50.0	290.0	619.1	73.0	140.0	140.0	120.0	110.0	80.0	80.0
Mizoram	55.0	150.0	313.0	60.0	62.1	62.1	65.0	67.5	60.0	62.0
Nagaland	68.0	180.0	289.0	58.0	60.0	48.0	50.0	47.1	47.1	47.0
Orissa	100.0	450.0	1120.1	411.2	271.7	433.8	438.8	480.1	322.8	205.8
Punjab	129.0	320.0	602.8	53.0	58.4	81.2	81.2	73.3	127.0	122.3
Rajasthan	150.0	498.5	3395.1	225.8	260.0	385.8	350.0	590.0	949.9	872.7
Sikkim	57.0	95.0	190.0	28.0	32.1	32.0	35.0	31.5	40.2	42.5
Tamil Nadu	590.0	700.0	2150.0	276.1	328.9	393.9	[?]	458.7	518.3	419.4
Tripura	123.9	150.0	272.5	57.5	65.5	58.2	61.0	36.0	60.0	47.1
Uttar Pradesh	709.0	1670.0	3795.4	566.0	755.0	664.4	492.0	408.5	535.5	731.8
West Bengal	220.0	504.5	1431.3	181.0	196.5	196.5	157.5	354.7	358.4	432.3
Union territory										
Andaman and Nicobar Islands	55.0	120.0	252.5	41.0	40.8	50.0	44.9	53.3	60.0	79.0
Chandigarh	6.0	16.2	86.0	23.2	20.0	20.0	22.5	10.2	18.3	8.6
Dadra and Nagar Haveli	13.0	42.9	80.0	15.3	12.0	17.0	20.0	25.0	26.0	26.0
Daman and Diu	—	—	11.0	2.4	2.0	2.0	2.0	3.3	3.7	3.6
Delhi	9.0	21.0	93.5	23.5	19.3	28.5	27.8	50.9	44.8	196.3
Lakshadweep	—	—	8.5	—	0.9	1.6	1.7	1.7	2.1	2.3
Pondicherry	2.8	13.0	26.7	4.7	5.0	5.8	7.3	9.6	11.0	10.9

Source
Planning Commission Annual Plans and Five-Year Plans (various issues) New Delhi: Government of India

For more details, please see TEDDY ONLINE+ [Section. Forest (Plan statistics)]

Table 12

Specific wood biomass fuel consumption in some rural industries

Industry type activities	*Value fuel consumed/unit product*
Cottage activities	
Roasted gari (Cassava)	3.0–40 kg wood/kg gari
Rice parboiling	0.3–0.4 kg husk/kg rice
Bread	0.6–2.kg wood/kg flour
Palm oil	7.0–9.0 kg wood/kg production
Smoked fish	0.2–16.0 kg wood/kg production
	1.4 kg coconut fronds/kg production
Cane gun	1.9 kg bagasse/kg production
Date palm gun	3.0 kg palm residues/kg production
Beer	0.4–1.0 kg wood/liter
Potteries	0.4–1.0 kg wood/kg production
Silk cocoon processing	14–34 kg wood/kg silk yarn
Village enterprises	
Bricks	0.3–1.5 kg wood/brick
	0.1–4.0 kg wood/kg brick
Ceramics	1.0–2.0 kg wood/kg pot
	0.6–0.8 kg wood/kg. pot
Tiles	0.2–0.5 kg wood/tile
Lime	2.0–.5 kg wood/kg lime
Breweries	0.2 kg wood/litre
Soap	0.4–0.6 kg wood/kg soap
Rural industries	
Bricks	0.3–1.5 kg wood/brick
	0.08–0.1 kg coal/kg brick
Tiles	0.2–0.5 kg wood/tile
Lime	0.6 kg wood/kg
Rubber/smoking	0.8–2.0 kg wood/kg production
	0.3–0.6 kg wood/kg RSS (rubber smoked)
Copra	0.5–1.5 kg wood + coco residue/kg
Tobacco	5.0–12 kg wood/kg cured leaf
	3.1–7.5 kg wood/cured leaf
Tea	1.5–2.0 kg wood/kg cured leaf
Coffee	0.75–2.0 kg wood/kg roasted bean

Source

Food and Agriculture Organization. 1996. Wood Energy News 11 (2) 16.

Table 13

Productivity of forests (m³/ha)

State/union territory/project	*Range*	*Average*
State		
Andhra Pradesh	22.7–80.2	60.9
Arunachal Pradesh	109.0–221.0	147.3
Assam	44.9–148.1	116.6
Bihar	16.7–61.46	37.5
Goa, Daman, and Diu	—	116.4
Gujarat	—	59.3
Haryana	—	13.9
Punjab	—	13.9
Himachal Pradesh	75.9–277.2	161.8
Jammu and Kashmir	130.9–276.4	226.2
Karnataka	7.3–79.4	56.4
Madhya Pradesh	32.4–82.9	63.9
Maharashtra	15.0–154.0	67.7
Meghalaya	80.2–100.7	—
Manipur	45.8–61.7	—
Mizoram	25.0–52.4	30.8
Nagaland	53.8–104.1	56.9
Orissa	37.0–61.0	57.0
Rajasthan	10.1–26.0	13.8
Sikkim	74.0–218.4	116.4
Tripura	—	23.1
Uttar Pradesh	14.4–185.4	109.6
West Bengal	5.0–225 3	32.0
Union territory		
Andaman and Nicobar Islands	75.0–268.3	157.1
Dadra and Nagar Haveli	—	53.0
Project		
FAO Project in Yamuna Catchment	—	201.0
FAO Project in Madhya Pradesh, Andhra Pradesh, and Orissa	—	61.6
FAO Project in Kerala and Tamil Nadu	—	87.8
All India	—	**77.3**

Sources

1. MoEF. 1993 The State of Forest Report. Dehra Dun: Forest Survey of India Ministry of Environment and Forests.
2. MoEF. 1995. The State of Forest Report. Dehra Dun: Forest Survey of India Ministry of Environment and Forests. 98. pp.
3. MoEF. 1997. The State of Forest Report. Dehra Dun: Forest Survey of India. Ministry of Environment and Forests. 72. pp.

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LOCAL AND GLOBAL ENVIRONMENT

Environment

Introduction

Most of the environmental problems that confront mankind today are connected to the use of energy in one way or another. Degradation and low accessibility of water resources, industrial pollution, and urban congestion are the major environmental issues that deserve high priority for India, besides land and soil resources, and deforestation (UNEP 1997).

The awareness of the environmental effects of energy production and its use in the transport, industrial, and domestic sectors is on the rise. The concern over environmental degradation brought about by increased consumption of fuels like coal and oil has been growing. The combustion of fuels in the industrial and transport sectors is the major source of emissions but domestic sources also pose potential health hazards.

The total costs of environmental degradation and pollution are unknown. The calculations performed by the World Bank add up to 4.5% of the GDP (gross domestic product) (World Bank 1996). These are rough estimates and should be viewed as lower bounds given the exclusion of several categories of costs.

Environmental laws and regulating agencies

A well-developed framework for environmental legislation did not exist in India until after the 1972 UN Conference on Human Environment (Stockholm) took place. In 1976, the constitutional sanction was given to environmental concerns through the 42nd Amendment, which incorporated them into the Directive Principles of State Policy (Article 48A) and Fundamental Rights and Duties (Article 51A(g)) (Thakur 1993).

Before a body of legislation focusing directly on the environment began to be developed, there were a number of older laws that addressed certain environmental concerns, such as the Indian Penal Code (1860). Calcutta adopted anti-smoke legislation in 1863, well before many European industrial centres. The Bengal Smoke Nuisance Act followed suit in 1905 (Anderson 1995). The Indian Easements Act (1882), which deals with rights in relation to pollution of waters, is yet another example.

The Water (Prevention and Control of Pollution) Act (1974) attempted to address pollution issues at a national level, in an integrated manner. (Please refer to Table 1 for a comprehensive list of environmental as well as environment-related laws.) The Air (Prevention and Control of Pollution) Act (1981) and the umbrella legislation brought out in 1986, namely, the Environment Act, covered the gamut of pollution problems, laying down the standards for pollution levels, etc. It was under the Water Act that the CPCB (Central Pollution Control Board) and the SPCBs (state pollution control boards) (pollution control committees in the union territories) were set up (CPCB 1998). They form a network of bodies responsible for controlling and monitoring environmental degradation.

The National Council for Environmental Policy and Planning, within the Department of Science and Technology, was set up in 1972 under the influence of the Stockholm Declaration brought out in the same year. It gradually evolved into the full-fledged MoEF (Ministry of Environment and Forests). This is now the apex administrative body responsible for regulating and ensuring environmental protection in the country. From Figure 1, which lays out the organization of the environment sector, it can be seen that MoEF[1] and the pollution control

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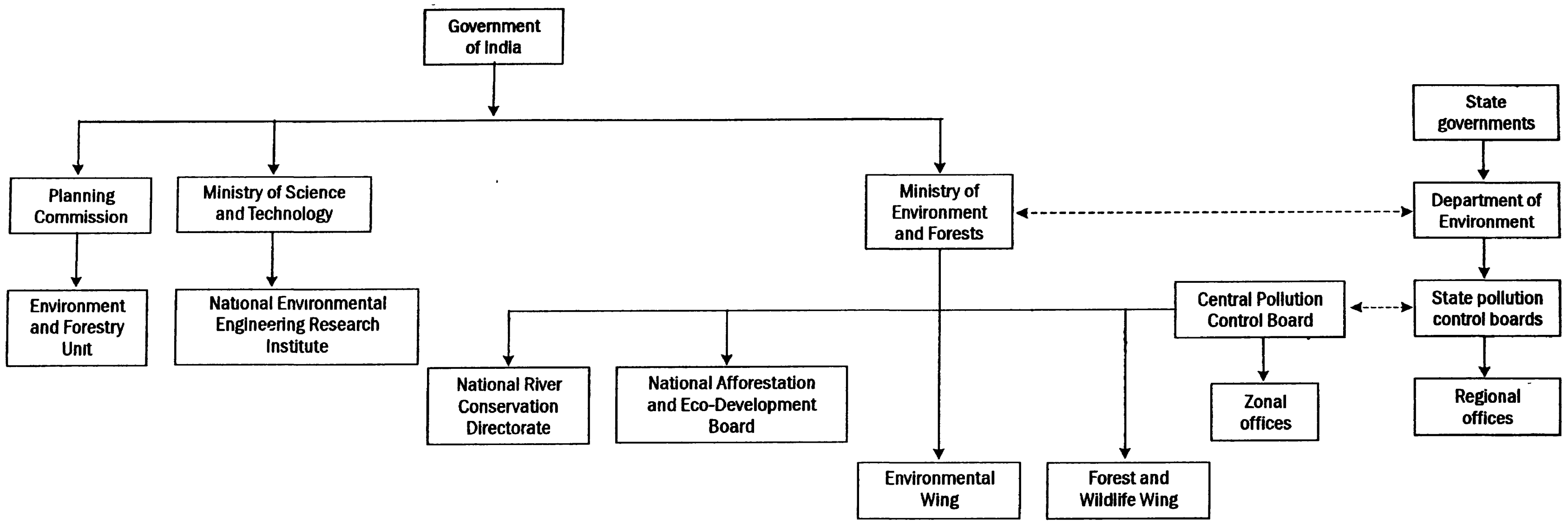
[1] For a reference to the internal organization of the MoEF, see *TEDDY 1998/99*.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Planning Commission
Ministry of Science and Technology
Ministry of Environment and Forests
State governments
Department of Environment
Environment and Forestry Unit
National Environmental Engineering Research Institute
Central Pollution Control Board
State pollution control boards
National River Conservation Directorate
National Afforestation and Eco-Development Board
Zonal offices
Regional offices
Environmental Wing
Forest and Wildlife Wing

Figure 1 The organization of the environment sector in India
Source MoEF (1997)

boards form the regulatory and administrative core of the sector.

The other bodies, namely, ministries and departments have within their supervision schemes and specified functions related to environmental management. The Ministry of Non-conventional Energy Sources, for instance, deals with the development of alternative sources of energy. There are a network of government and non-government research institutes and laboratories that are involved in monitoring, reporting, and studying environmental pollution.

There are numerous other bodies that may not be directly linked to the environment sector but form an integral part of it. The Eleventh Schedule of the 73rd Constitutional Amendment made in 1992 is related to the panchayats, and addresses issues of environmental protection and conservation. Panchayats are bestowed with responsibilities in the areas of soil conservation, water management, watershed development, social and farm forestry, drinking water, fuel and fodder, non-conventional energy sources and maintenance of community assets. The 74th Constitutional Amendment Act, 1992, added the Twelfth Schedule to the constitution, which pertains to urban local bodies. It relates to their constitution as well as specifies their functions of protection of environment and promotion of ecological effects.

A policy framework that complements the above laws and constitutional sanctions has also been developed. Referred to here are the two policy statements of 1992, namely, the *Policy Statement for Abatement of Pollution* and the *National Conservation Strategy and Policy Statement on Environment and Development* brought out by the MoEF. The former draws attention to the changed stance within the environment sector such that the development and promotion of voluntary initiative for protection and improvement of the environment, through the use of incentives, is simultaneous to the development of the regulatory and legislative framework. These incentives may be fiscal or financial with the intention of encouraging cleaner technologies and production practices and deterring the use of harmful and polluting practices.

Following close on the heels of the above two policy statements came the Environment Action Programme (MoEF 1993). The stated objective of the Programme is to prepare a 'blueprint' for integrating environmental concerns into the development process. The intention is to formulate a blueprint that is dynamic and holistic and promotes a decentralized system of environmental management. The formulation of a comprehensive national policy on the environment is currently in process in the government. The National Water Policy was adopted in 1987, with the aims of ensuring optimum though environmentally sound utilization of water resources, and dealing with the high pollution levels.

International agreements and conventions also come under the ambit of environmental law. India, for instance, is a signatory to the Basel Convention (1989) on the control of transboundary movement of hazardous waste and its disposal (CII 1999). Being a signatory, India has made efforts to amend to the earlier rules on waste management.

Environment and development

The Ninth Five-Year Plan (1997–2002) focuses on sustainable development as one of its objectives. This implies realizing the symbiotic relationship between the processes of environmental protection and improvement, and that of development. The budgetary outlays are planned accordingly. The expenditure of the MoEF in the Eighth Plan was 16 319 million rupees (current prices) as against the allocation of 12 000 million rupees (1992 prices). In 1998/99, however, the MoEF spent 5730 million rupees against the allocated 8200 million rupees. This seems to indicate that the amount of budgetary support cannot be taken to be an indicator of the importance, or the lack of it, given to environmental concerns.

The need to fulfil the stated Ninth Plan objective of integrating such concerns into the process of development grows stronger. Table I highlights some impacts of this process on the environment.

The costs of degradation that result from the above activities are very high. The findings of TERI's *GREEN India 2047* study (TERI 1999) are as follows.

- The economic loss due to soil degradation was 89–232 billion rupees annually, a loss of 11%–26% of agricultural output.
- Air pollution has significant health impacts. For each urban resident, it comes to about 600–1500 rupees a year, and for each slum dweller, it could be as high as 2000–7400 rupees a year.
- The incremental annual cost of ensuring safe drinking water and adequate sanitation facilities to all is 122 billion rupees. As a contrasting estimate, the World Bank estimated health impacts related to water quality to be 107 billion rupees.

Table 1 Impact of development activities on the environment

Development activities	Major impacts on environment
Shifting cultivation in upland agriculture	Soil erosion in upland areas, soil fertility declines due to shorter cultivation cycle, flooding of lowland areas
Agro industries	Air pollution due to burning of bagasse as fuel in sugar mills, large amount of highly polluting organic wastes, surface water pollution
Introduction of new varieties of cereals	Reduction of genetic diversity of traditional monoculture resulting in instability, danger of multiplication of local pests or local strains of fungus, bacteria or virus on new variety
Use of pesticides	Organisms develop resistance and new control methods are needed (e.g., in malaria, widespread use of dieldrin as a prophylactic agent against pests of oil palms made the problem worse), creation of complex and widespread environmental problems
Timber extraction	Degrades land, destroys surface soil, reduces production potential of future forests
Urbanization and industrialization	Concentration of population making huge demands on rural environment, air and water pollution
Water resources projects, e.g., dams, extensive irrigation	Human settlement and resettlement, spread of water-borne diseases, reduction of fisheries, siltation, physical changes, e.g., temperature, humidity

Source CSO (1998)

Environmental standards

Standards for ambient air quality, water quality, noise levels, vehicles with controlled pollution levels, specific industries, etc. are developed to monitor and regulate pollution levels. Pollution levels all over the country are being monitored by various agencies and the status of pollution control is improving due to increasing efforts on the part of the government and rising awareness amongst the industries. During the course of the year, more standards have been introduced, regarding which notifications have been issued by the MoEF. These are added under the relevant sub-sections.

Ambient air quality standards

Faced with the growing problems of air pollution, a number of countries have established ambient air quality standards to protect the environment. India too, under Section 16(2)(h) of the Air (Prevention and Control of Pollution) Act, 1981, has enforced ambient air quality standards. Till early 1994, these were based on an eight-hourly averaging time only. In April 1994, these standards were revised to 24-hourly standards. The NAAQS (national ambient air quality standards) are prescribed for three distinct areas: (1) industrial; (2) residential, rural, and other; and (3) sensitive. In a notification brought out in November 1998, the standards for ammonia have been added to the national ambient air quality monitoring standards (Tables 2 and 3).

Of late, noise has been recognized as a pollutant, which, until recently, was considered only as a nuisance. The CPCB has notified the ambient noise standards in 1987 under Section 20 of the Air (Prevention and Control of Pollution) Act, 1981. In terms of additions to the standards as specified in Table 4, noise standards for 15–500 kVA generator sets / stationary diesel generator sets have been notified as lying between 85 and 90 dB (A). Studies of noise levels conducted in a few major cities seem to indicate that these levels are barely within limits in industrial zones but due to vehicular noise, the pollution limits in residential, silence, and commercial zones are being challenged more and more everyday (MoEF 1999).

Water quality standards

Drinking water standards for India were set up by the ICMR (Indian Council of Medical Research). These are almost similar to the WHO (World Health Organization) drinking water standards. The USPHS (United States Public Health Service) has even more stringent standards.

For industries, surface water is the main source for drawing water for industrial purposes and discharging effluents. The water quality in surface water bodies depends on discharges at various stretches. Based on water quality criteria, the CPCB has designated water uses for all Indian rivers. This is done through classification of surface water into five categories, namely, A, B, C, D, and E in decreasing order of quality (Table 5).

Discharges of industrial effluents are regulated through Indian Standards Codes – IS:2490 (1974) for discharges into inland surface waters, IS:3306 (1974) for discharges into public sewers, and IS:3307 (1974) for discharges on land for irrigation (Refer to Table 6 for general effluent discharge standards. For industry-specific standards, see Tables 7–12, and Table 13 for thermal power plants.)

Recently, water quality standards for coastal waters' marine outfalls have been specified.

Industrial emission standards

Industries consume energy mostly in the form of fuel for combustion and for feed material in a few cases. Air-borne emissions from various industries are a cause for major concern. These emissions are of two forms: (1) particulate emissions such as SPM (suspended particulate matter), and (2) gaseous emissions such as sulphur dioxide, oxides of nitrogen, and carbon monoxide. Liquid effluents, generated from certain industries, containing organic and toxic pollutants are also a cause for serious concern. Heavily-polluting industries have been identified and are included under the 17 categories of highly-polluting industries for the purpose of monitoring and regulating pollution.

The MoEF has, over the past two decades, developed standards for regulating emissions from various industries and set emission standards for all polluting industries including thermal power stations. Among the most recent additions are the standards for gas-/naphtha-based thermal power plants (Tables 14–16). Industry-specific standards are also specified for iron and steel plants, cement plants, etc. (Tables 17–24). Most of the air quality emission standards include permissible limits for SPM and in a few cases sulphur dioxide, where it is the prime pollutant, while no standards for oxides of nitrogen and carbon monoxide are specified. The health risks of radioactive exposures can be fatal as has been recorded in the past. The International Commission on Radiological Protection has specified the standard for maximum permissible radioactive dose as one millisievert (excluding natural background levels).

Vehicular emission standards

The share of vehicular pollution in urban areas is reaching serious proportions (emission factors for different vehicles are given in Table 25). Vehicular emission control is also increasingly gaining attention. Vehicular emission standards were first set in 1986 by the CPCB for both petrol- and diesel-driven vehicles. These were later revised in 1987 and 1989. The prevailing standards for petrol-driven vehicles for carbon monoxide are 3% for two- and three-wheelers and 4.5% for four-wheelers (Table 26). The standards for diesel-driven vehicles specify limits for smoke as 65 Hartridge units (Table 27).

These, however, are emission standards with reference to volume of air. They do not constitute mass emission norms, the first stage of which came out in 1991 for petrol vehicles and in 1992 for diesel vehicles. The next stage of mass emission norms, Euro I, is to be initiated from 2000. And compliance with the next stage, the one enforced in Europe at present – Euro II norms – is to be initiated in 2005. On 29 April 1999, the Supreme Court brought forward the introduction of both stages of emission norms by ordering a move to disallow registration of all private non-commercial vehicles in the NCR (National Capital Region) failing to conform to Euro II fuel emission norms from 1 April 2000. The order forces automobile manufacturing companies to meet Euro I norms by 1 June 1999 and Euro II norms by 2000. Tables 28 and 29 compare standards specified at all of the above stages.

To conform to the Euro I and II norms, the quality of petrol and diesel has to adhere to specific fuel properties. These must include, initially, reduction or substitution of lead in petrol and reduction of sulphur in petrol and diesel. Also essential would be a complete or near complete elimination of sulphur, aromatics, and heavy oils in diesel, and lead in petrol by using an oxygenated supplement like methyl tertiary butyl ether. However, there are no references to fuel quality in the Supreme Court order although fuel specifications are as integral to the shift to Euro norms as the technology used by the car manufacturers. Also, they hold particular importance for India at present as the Bureau of Indian Standards' specifications for petrol and diesel quality that exist as of now do not enable emissions that are up to the Euro standards; neither Euro I nor Euro II. They were set before Euro norms came into prominence in India (Bose 1999).

The early enforcement of the Euro norms has been preceded by a number of measures being introduced in the NCR recently. For instance, the

Supreme Court has also taken measures such as restricting the plying of commercial vehicles like trucks in the daytime. Other measures pertain to the introduction of unleaded petrol, which has now been made available in 42 major cities. By 2000, it will be made available throughout the country. As of now, low-lead petrol with a maximum lead content of 0.15 g/litre has been introduced throughout the country. Low-sulphur diesel, with a sulphur content of 0.5% or less, has been introduced in the four metros of Delhi, Mumbai, Calcutta, and Chennai from 1996. In Delhi and the Taj Trapezium area, the sulphur content in fuel has been further reduced. Compressed natural gas has been introduced for some categories of commercial vehicles.

The MoST (Ministry of Surface Transport) stipulated, in a notification brought out in 1998, that all four-wheeled petrol-driven vehicles registered after August 1998 in specified cities were to be fitted with catalytic converters. Emission norms for passenger cars fitted with catalytic converters were to be 50% lower than for cars without them (Table II).

Two-stroke engine vehicles are among the most polluting categories of vehicles. In 1998, the standards of the respective oils were specified, to be effective from April 1999. Also, pre-mixed fuel (petrol and oil) is being made available at petrol stations. Expansion of the availability of pre-mixed oil dispensers (petrol and 2T oil) shall be undertaken along with a ban on the supply of loose 2T oils at petrol stations and service garages.

Table II Emission norms for petrol-driven vehicles, with reference to catalytic converters*

	Emission standards for petrol-driven four wheelers	
Pollutant	*Without catalytic converter*	*With catalytic converter*
Carbon monoxide (g/km)	8.68-12.40	4.36-6.20
Hydrocarbons + oxides of nitrogen (g/km)	3.0-4.36	1.5-2.18
Total (carbon monoxide + hydrocarbon + oxides of nitrogen)	11.68-16.76	5.84-8.38

* these norms have been notified by the MoST on 21 January 1998.
Source MoEF (1998)

One of the most significant lacunae in rules for controlling vehicular emissions was that they did not give sufficient consideration to older vehicles plying on the roads, with older or at times obsolete, and thus highly polluting, technology. This is now being given its due importance with the government bodies as well as the Supreme Court coming down hard with a programme of phasing them out.

Hazardous waste rules

The MoEF has framed the Hazardous Wastes (Management and Handling) Rules, 1989, under the Environment (Protection) Act, 1986. It brought out a guide for the manufacture, storage, and import of hazardous chemicals in 1989 and set guidelines for the management and handling of hazardous wastes in 1991. The Manufacture, Storage, and Import of Hazardous Chemicals Rules list 434 toxic flammable and explosive chemicals, which require careful regulation.

The Hazardous Wastes Rules list 18 types of waste categories with its regulatory quantity, which, if exceeded by any industry has to comply with the various management and handling rules. Draft amendments were made in 1997 to the Hazardous Waste (Management and Handling) Amendment Rules (1989). They were made under the influence of the Basel Convention. The amendment was related to the import and export of hazardous wastes as well as categorizing the different types of waste.

Bio-medical waste rules

In 1998, the MoEF issued the Management and Handling of Bio-medical Waste Rules. They contain guidelines with regard to the disposal, segregation, transport, etc. of infectious wastes generated by treatment of, as well as research activities related to, human beings or animals. Thus, it is the responsibility of hospitals, blood banks, pathological laboratories, etc. to handle such waste without any adverse effect to human health or the environment. (Refer to Table 31 for the various categories of bio-medical waste specified.)

Environmental scenario

India is one of the 10 most industrialized countries in the world. Increasing urbanization, industrialization, deforestation, transportation, and high-intensity agriculture are some of the major causes of environmental problems being faced by the country.

Air pollution

Although India has made great strides in recent years in managing environmental issues, urban environmental degradation is heading towards a crisis. Six of the largest cities in India have severe air pollution. Annual average levels of total SPM in these cities are at least three times the WHO standard. More than 90% of the national monitoring stations record particulate concentrations exceeding 75 $\mu g/m^3$, the recommended standard issued by the WHO.

The CPCB has been regularly monitoring the ambient air quality at 290 locations spread over 92 cities/towns, and water quality in all the major rivers at 402 locations under MINARS (monitoring Indian national aquatic resources systems), 51 locations under GEMS (global environmental monitoring systems), 27 locations under GAP (Ganga Action Plan), and 134 locations for groundwater.

The monitoring data revealed that the status of air quality was bad in Howrah, Calcutta, in 1994, and worse in Gajraula, Uttar Pradesh, in 1993. The CPCB has also identified 24 locations as problem areas in the country (Figure 2). Two new problem areas have emerged, namely, Kala Aam and Parwanoo, both in Himachal Pradesh (Trivedi 1998). Table 30 compares the status of cities with respect to highly polluted air quality levels. Average noise levels in various metropolitan cities are given in Table 32.

The emissions from industries vary, as there is a wide range of fuel types used and industrial processes. However, the important pollutants from industries are SPM, carbon monoxide, sulphur dioxide, and oxides of nitrogen.

Industry

Industrial growth has been accompanied by a variety of environmental problems. Whereas industrial output grew fourfold between 1963 and 1991, toxic releases grew sixfold as shown in Table III (World Bank 1996). There were 1551 industries in the country falling under the 17 categories of highly polluting industries as on 31 March 1996. The status of pollution control in these industries is given in Figure 3 (More details are given in Table 33, and Table 34 contains a statewise summary regarding these 17 categories). Thermal power, sugar, pulp and paper, and distillery emerge as the major defaulters in meeting air pollution standards.

Table III Industrial contribution to pollution by sub-sector

	Share of total pollution (%)		
Sector	*Particulates*	*Sulphur*	*Nitrogen*
Industrial chemicals	8	11	15
Iron and steel	23	2	5
Non-ferrous metals	3	1	0
Other chemicals	1	0	1
Food products	11	4	8
Paper and pulp products	4	15	11
Non-metallic mineral products	32	3	10
Petroleum refineries	6	31	21
Textiles	6	30	23

Source World Bank (1996)

Power

Thermal power constitutes about 72% of the total installed power generation capacity. Coal-based thermal power generating capacity of the country by the end of 1994/95 was 58 169 MW. Increasing reliance on thermal power leads to many environmental problems. India's coal is very high in ash content (35%–40%), disposal of which is a major problem. Further, the quality of coal available to the thermal power stations has declined considerably. The poor quality of coal results in greater consumption of coal per unit of electricity generated and, therefore, leads to higher emissions per unit of generation and increased problems of ash disposal.

The MoEF, in a notification issued in 1997, made it imperative for TPPs (thermal power plants) located beyond 1000 km from the coal pit-head, or in urban, sensitive or critically-polluted areas, to use coal with an ash content lower than 34%. The coal used by such TPPs after 1 June 2001, the date specified, is to be beneficiated coal, i.e., coal containing a lower ash content in the raw coal obtained through physical separation or through the washing process.

Transport

Vehicular emissions are assuming alarming proportions in urban areas. The salient problems associated with vehicular pollution are emissions from older vehicles plying on their road and the fact that they are often not well maintained.

The emissions causing concern are carbon monoxide, oxides of nitrogen, unburned hydrocarbons, and particulates. Petrol-driven vehicles are a major

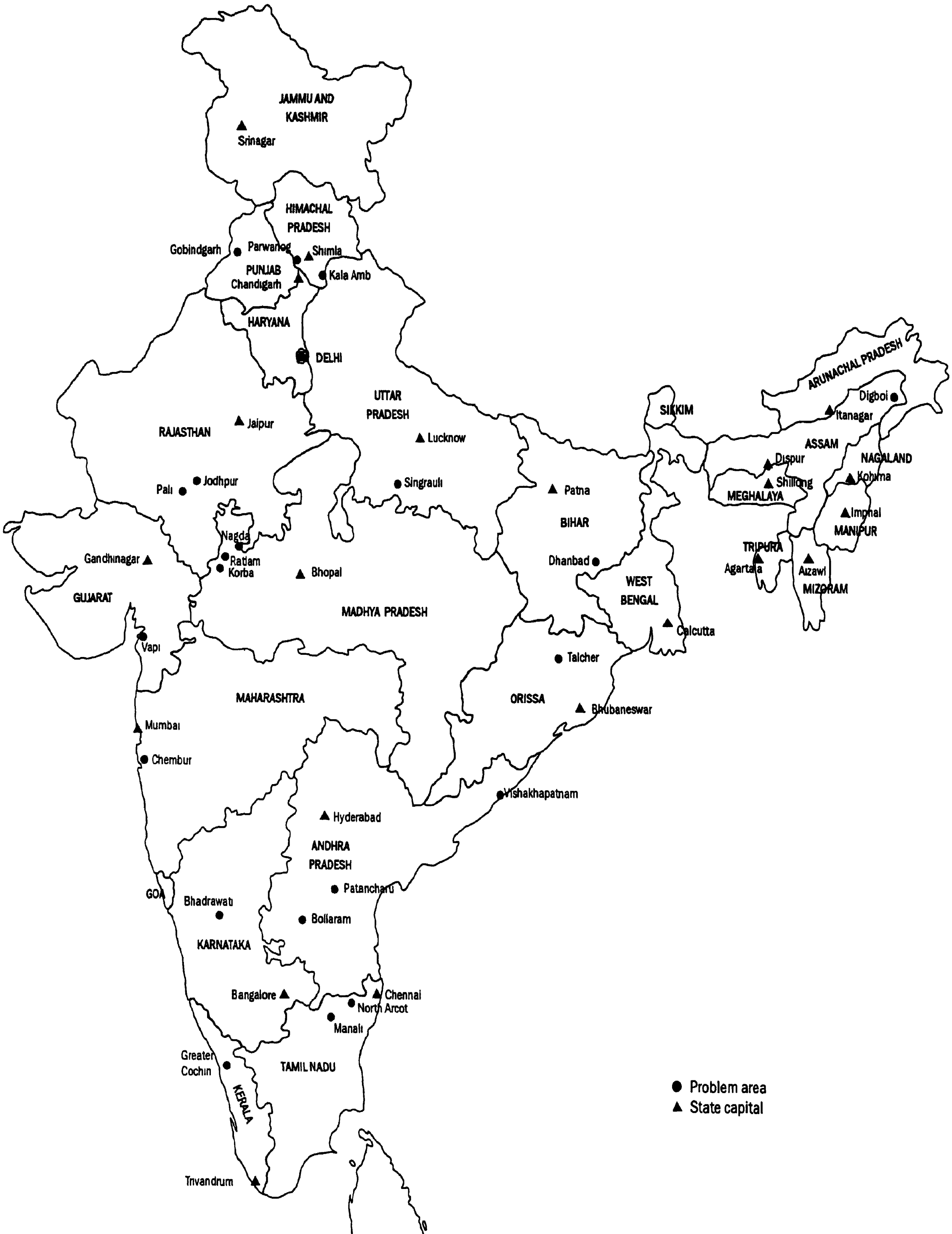

Figure 2 Problems areas in India with respect to air quality

Source CPCB (1995a)

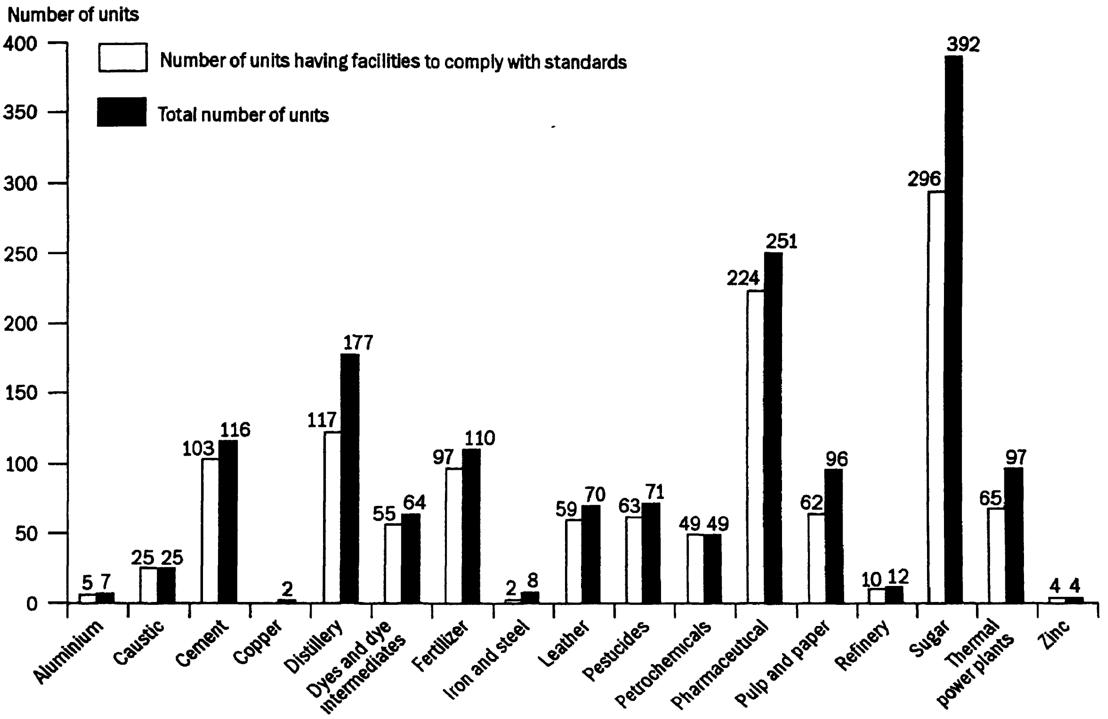

Figure 3 Status of compliance by 17 categories of highly-polluting industries
Source CPCB (1997)

source of carbon monoxide emissions contributing over 85% and diesel-driven vehicles contributing over 90% of emissions of oxides of nitrogen. Emission of hydrocarbon and carbon monoxide from the large two- or three-wheeler population and the emissions of oxides of nitrogen from diesel vehicles are very high. The daily pollution load generated due to automobiles in the four metropolitan cities is shown in the Table IV.

Table IV Estimated emissions of pollutants from vehicles in metropolitan cities: 1994

	Amount of pollutant (tonnes per day)					
City	*Particulates*	*Sulphur dioxide*	*Oxides of nitrogen*	*Hydrocarbons*	*Carbon monoxide*	*Total**
Delhi	10.3	9.0	126.5	249.6	651.0	1046.3
Mumbai	5.6	4.0	70.8	108.2	469.9	659.6
Calcutta	3.3	3.7	54.7	43.9	188.2	293.7
Chennai	2.3	2.0	28.2	50.5	143.2	226.3

* may not add up exactly due to rounding off
Source CPCB (1995)

Even though the vehicular population is increasing at a phenomenal rate, it is still low compared to several European countries and the US. In spite of this, vehicular pollution has become a serious problem in urban areas. The different factors attributable are the types of engines used, the age of vehicles, poor road conditions, and congested traffic. The fuel used is also of great importance. Also, the adulteration of fuels and use of spurious lubricants is a very worrying factor. However, now the availability of pre-mixed fuels (refer to vehicular emission standards) should help to deal with this problem.

A holistic approach needs to be taken to this problem. Enforcement of the Euro II norms will have to be supplemented with more care towards fuel quality, for instance. Also, long-needed attention is finally being turned towards older vehicles plying on the roads. The road network itself is beginning to draw attention. A recently introduced bill has hiked up excise, which will be fed into investment for developing and improving the network. (For more details, see the chapter on *Transport*.)

Domestic

1991, the World Bank rated indoor air pollution developing countries as one of the four most itical global environmental problems. Emissions om domestic fuel consumption are also of sig-ficance since a large proportion of the popula-n is involved in domestic cooking activities. llutants of concern from such sources are SPM d carbon monoxide. Cumulative exposure to ch pollutants is often more damaging to health an exposure to larger sources of pollution.

Some studies related to indoor air pollution show at the concentration of SPM during a cooking ssion varies from 3–6 mg/m^3 and that of carbon onoxide from 5–50 parts per million. Women in ral households have to cope with a daily pollu-n load equivalent to spending one hour in a room at has as much as 40 mg of SPM for every cubic etre of air, as against a value of 1.2–3.0 mg sug-sted by the WHO.

Water

ater is polluted by four kinds of substances: tra-tional organic waste, waste generated from in-strial processes, chemical agents for fertilizers d pesticides for crop protection, and silt from graded catchments. While it is estimated that ree-fourths by volume of the waste water gener-ed are from municipal sources, industrial waste, ough small in volume, contributes over one half the total pollution load.

The types and sources of water contamination clude 'point' sources of pollution, which usually fer to wastes being discharged from a pipe and on-point' sources, which mean all other sources ch as stormwater runoff (which picks up oil and her contaminants from various areas), irrigation hich carries fertilizers and pesticides into oundwater), and leaks.

The pollution problems in small towns are basi-lly associated with water. A survey of 241 Class towns in 17 states in India undertaken by the PCB indicates that, on an average, 90% of the ater supplied is polluted. Only 1.6% of the total olluted' waste water gets treated (CPCB 1990). most all the major rivers in India are increasingly teriorating in their water quality. The list of pol-ted river stretches is ranked in Table 35 along with ssible sources of pollution. The Godavari, Krishna, d Indus rivers owe their pollution load predomi-ntly to industrial activities. Municipal/domestic and industrial wastes are the major pollution sources for other rivers.

Industry

Industrial units located primarily in densely populated urban areas discharge their effluent untreated into surface water channels, land sites, and sewers. Reliable data regarding the share of industrial pollution in the total pollution load are hard to come by. The MoEF estimates that industrial pollution contributes more than one-third of the total pollution in rivers and other bodies of water. According to the CPCB, there exists 1532 grossly polluting industries that discharge into water courses (CPCB 1996) (Table 36).

Proliferation of industries, particularly the small-scale units, has resulted in a concomitant rise in water pollution. Sugar, distillers, synthetic fibre, pulp and paper, soap and detergents, dyestuff, and tanneries are the major contributors to water pollution. Sugar and pulp and paper industries are the major defaulters in complying with the norms for liquid effluents. The share of different industries in surface water pollution is shown in Table V.

Table V Share of different industries in surface water pollution (water pollution in terms of biological oxygen demand)

Industry	*Share (%)*
Food products	38
Industrial chemicals	29
Paper and pulp products	19
Non-ferrous metals	10
Petroleum refineries	2
Other chemicals	1
Textiles	1

Source World Bank (1996)

Domestic

Domestic sewage is the primary source of water pollution in India especially in and around large urban centres. In India, as per the census data of 1991, about 82% of the urban households had access to safe drinking water and 64% had toilet facility. The corresponding percentage for the rural households stood at 56% and 9%, respectively.

A survey carried out by the CPCB in 212 cities in India reveals that the problem of waste water collection and disposal has become acute (CPCB 1990). In 45 major cities with a total population of nearly 65 million, the waste water generated is 9493 million litres per day while the sewerage system can only collect and treat 2357.48 million litres per day. The sewerage capacity forms just 25% of the total waste water generation in these cities. The report says that 'so long as major cities in India continue to discharge their waste water untreated into rivers, lakes, and ponds, no improvement is possible in the quality of water' (CPCB 1990).

Agriculture

Certain agricultural practices like increased use of nitrogenous fertilizers affect the water quality indirectly. Nitrate is one of the forms of nitrogen taken by plants. Through leaching, nitrate finds its way into groundwater, which is a potential threat to potable water quality (Table 37). The maximum permissible limit laid down by the WHO for nitrate content of drinking water is 100 mg/litre. In India, studies have shown that in some parts of the country the nitrate content of dug wells was higher than the permissible limits.

Adverse impacts of pesticide use can also be observed in water. Pesticides are carried by irrigation water or rain and get transported into the ground to mix with groundwater reserves. This is also affected by leaching, runoff or other related mechanisms. A long-term policy for pesticide use, including the introduction of environmentally acceptable pesticides, particularly bio-pesticides and non-persistent biodegradable ones, and integrated pest management together with the phasing out of the proven harmful toxic and persistent ones would be formulated in collaboration with the concerned ministries and infrastructure involved for its effective implementation.

Municipal solid waste

Environmental concerns are echoed in the executive summary to the Ninth Five-Year Plan. It recognizes that the health and environmental consequences of increasing population density, lack of safe drinking water, and inadequate urban sanitation have to be tackled through a proper urbanization policy with programmes for disease surveillance, epidemic control, and urban solid and liquid waste management (Planning Commission 1998).

The amount of MSW (municipal solid waste) generated in most Indian cities is increasing rapidly (Table 38). The per-capita quantity increases with the size of the city and varies between 0.2–0.4 kg per capita per day. In metropolitan cities, values up to 0.5 kg per capita per day have been recorded. Per-capita waste generation is also increasing over the years at the rate of 1.33%. It is roughly estimated that Indian cities and towns generate about 4000 tonnes of municipal wastes every day and almost all the wastes find their way to landfill sites, which are seldom managed in an environmentally acceptable manner. Table 39 displays the characteristics of MSW generated in the major cities of the country.

The MSW generation and collection efficiency for 1994 is shown in Table VI for nine major Indian cities. The management of MSW needs urgent attention, which includes collection, disposal, and transportation to the landfill sites. There is evidence that in the metropolitan cities, the performance is dismal.

Table VI Municipal solid waste generation and collection in major Indian cities, 1994

City	*Generated (tonnes/ day)*	*Cleared (tonnes/ day)*	*% collected*
Ahmedabad	1500	1200	80
Bangalore	2130	1800	85
Mumbai	5800	5000	86
Calcutta	3500	3150	90
Delhi	3880	2420	62
Lucknow	1500	1000	67
Chennai	2675	2140	80
Patna	1000	300	30
Surat	1250	1000	80

Source Living Media India Ltd (31 October 1994)

The CPCB conducted a two-year survey on the management of MSW by the two civic agencies, the Municipal Corporation of Delhi and the New Delhi Municipal Corporation. The report concluded that there is no significant change for the better in the overall management of solid waste. One of the most alarming failings of the civic agencies revealed in the report is that the air, water, and land components of the environment at the landfill sites are grossly polluted.

It is estimated that currently the solid and hazardous waste generation from the industrial sector is of the order of 90 million tonnes and 600 000 tonnes a year, respectively (Tables 40 and 41). The industries that generate huge quantities of waste are: thermal power stations about 70 million tonnes of coal ash annually), and iron and steel plants (8.5 million tonnes). In addition, others such as non-ferrous metal industries, sugar, and fertilizer industries similarly generate large quantities. Disposal of these wastes is largely uncontrolled; dumping on public land or in MSW sites is quite common.

Environment and health

Environmental pollution implies the introduction of chemicals or agents into the physical environment that either did not exist, or did not exist in the same large scale, earlier. The impacts of pollution and depletion of resources like pure air (indoor as well as outdoor), soil and ground and surface water sources, on the health of the human population is considerable, and growing. That respiratory infections and water-borne diseases are the major causes of mortality is evident from Table 42. On a direct level, health impacts are related to sanitation and hygiene. Health-related policies and implementation programmes in India focus predominantly on this aspect. Little attention is paid, however, to indirect effects, such as those resulting from high levels of pesticides and other chemicals that accumulate in food. Stress factors, for instance, are associated with high noise levels (Saksena 1998).

Rural dimension

Health problems caused by environmental pollution have rural and urban dimensions. In rural areas, factors that are affected by changes in the environment are land availability, forest cover, accumulation of agrochemicals in food, and indoor air pollution.

With the onset of land scarcity and depleting forest cover, poverty levels are heightened. This is accompanied by an increase in drudgery, as a result of having to go further in search of water, fuelwood, etc. The quality of drinking water is also not monitored and poses a great risk that involves diseases like amoebic and bacillary dysentery, cholera, diarrhoea, hepatitis, typhoid, and guinea worm. Scabies, leprosy, conjunctivitis, and trachoma also belong to the category of diseases caused by impure water.

A very important factor among the aforementioned is that of indoor air pollution. Among rural households, 90% use biofuels for cooking. These are inefficient polluting fuels such as firewood, dung or crop residues. To add to this, cooking is usually done in small, ill-ventilated kitchens on inefficient traditional stoves. Pollutants from cooking stoves (for various fuel–stove combinations) are given in Table 43. The ranges of concentration of pollutants as have been measured in a few studies are given in Table 44.

The impacts caused fall into four major categories of ill health.

1 Respiratory infections in young children
2 Adverse pregnancy outcomes for women exposed during pregnancy
3 Chronic lung diseases and associated heart disease in adults
4 Cancer

Urban dimension

The urban dimension of environmental health problems is manifested typically in slum areas. These areas suffer because of unequal access to land, public utilities, and urban infrastructure. Drainage and drinking and other water systems are in close contact, thus making them highly polluting. Slums are usually located in the proximity of major industries and road intersections, which has a very negative impact on the ambient air quality, etc. Thus, both indoor as well as ambient air quality leave a lot to be desired.

The MoEF has been conducting environmental epidemiological studies that aim to establish the health impacts of pollution. The importance of these studies lies in the fact that they could help determine specific environmental changes, and develop health indicators, etc. These sorts of impacts are very hard to determine on a sound medical footing and any studies carried out hold a lot of significance.

The only major epidemiological study of air pollution related illnesses was conducted in Mumbai. The health morbidity for cough, dyspnoea, common colds, eye irritation, headaches, etc. showed a clear and strong relation to the profile of three pollutants – nitrogen dioxide, sulphur dioxide, and SPM. Lung functions were less efficient in the more polluted areas and respiratory symptoms went up according to how high the sulphur dioxide levels were.

Significant achievements in the environmental sector since Independence

Laws pertaining to the environment are growing in number. The past decade especially has seen a spate of environmental or environment-related laws. These vary from rules related to the storage and disposal, etc. of hazardous wastes (1989), chemicals (1989) and microorganisms (1989) to the National Environment Appellate Authority Ordinance (1997), which provides for the establishment of an authority to hear appeals regarding restriction of areas for industrial or other development activities. Thus, a more holistic view of environmental issues is developing.

The 73rd and 74th Constitutional Amendment Acts, both made in 1992, establish the devolution of powers to the panchayats and the urban local bodies, respectively. The amendments also influence the development of a decentralized structure for environmental management as well as for a more effective relationship between environment and development, down to the local level. The National Conservation Strategy and Policy Statement on Environment and Development (1992) addresses this relationship directly.

The Policy Statement for Abatement of Pollution (1992) represents the change in the regulatory structure of the environment sector, which is gradually diversifying from a purely command-and-control *modus operandi* to market-based incentives. Depreciation allowances, exemption from excise or customs duty payment, and arrangement of soft loans for the adoption of clean technologies are instances of such incentives.

Another shift in approach that is evident is from a focus on the end-of-pipe treatment of pollution to a focus on cutting it out at the source, i.e., through clean technologies as well as housekeeping practices that maximize waste utilization and minimize its generation. However, in order to see this approach through, large financial investments and a considerable degree of institutional restructuring are involved. Environmental impact assessments have been made mandatory for 29 categories of development activities. This helps highlight the possible short- and long-term environmental impacts of such activities in the very beginning, and also lays out plans for their removal or mitigation. Table 45 contains a list of projects requiring environmental clearance.

A culture of environmental consciousness is spreading and drawing in more stakeholders. With an increase in the awareness of civil society, public interest litigation cases are on the rise and are also spurring judicial institutions into (pioneering) action. Implementation of the stringent norms for vehicular emissions has been brought about recently by the force of none other than the apex court of the country. The Supreme Court has also tried to encourage the high courts to take a more proactive stance.

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India's Environment: taking stock of plans, programmes, and priorities
Washington, DC: World Bank. 317 pp.

Table 1

Environmental legislation, acts, rules, notifications, and amendments

General	The National Environment Appellate Authority Ordinance, 1997
	The Environmental Clearance Notification, 1994
	Notification on Environmental Impact Assessment (EIA) of Development Projects, 1994
	The Environmental Standards Notification, 1993
	The Environmental Audit Notification, 1992
	National Conservation Strategy and Policy Statement on Environment and Development, 1992
	The National Environment Tribunal Bill, 1992
	Policy Statement on Abatement of Pollution, 1992
	The Public Liability Insurance Act, Rules, and Amendment, 1992
	The Public Liability Insurance Act, Rules, and Amendment, 1991
	The Environment (Protection) Act and Rules, 1986
Land	Involvement of Village Communities of Voluntary Agencies in Regeneration of Degraded Forests, 1990
	National Forest Policy, 1988
	The Industries (Development and Regulation) Act and Amendment, 1987
	The Coal Mines (Conservation and Development) Amendment Act, 1985
	The Model Regional and Town Planning and Development Law, 1985
	The Mines and Minerals (Regulation and Development) Act and Amendment, 1984
	The Forest (Conservation) Act, 1980
	The Urban Land (Ceiling and Regulation) Act, 1976
	The Mines and Minerals (Regulation and Development) Act and Amendment, 1957
	The Industries (Development and Regulation) Act and Amendment, 1951
	Provision in State Acts on Town and Country Planning
	Wildlife Protection Act
	Draft Notification on Fly Ash Utilization
Water	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1992
	The Coastal Regulation Zone Notification, 1991
	The Oil Fields (Regulation and Development) Act, 1984
	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1978
	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1977
	The Water (Prevention and Control of Pollution) Cess Act, 1977
	The Merchant Shipping Act, 1970
	The Indian Fisheries Act, 1897
Air	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1987
	The Factories Act and Amendment, 1987
	The Motor Vehicles (Amendment) Act, 1986
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1983
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1982
	The Atomic Energy Act, 1982
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1981
	The Indian Boiler Act, 1923
	Notification on restriction of ash content of coal to be used in TPPs
Hazardous chemicals/wastes	Bio-medical Waste (Management and Handling) Rules, 1998
	Draft Hazardous (Management and Handling) Rules, 1997
	Manufacture, Use, Import and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells Rules (1989)
	The Hazardous Wastes (Management and Handling) Rules, 1989
	Manufacture, Storage, and Import of Hazardous Chemicals Rules, 1989

Source

Complied by TERI from various sources

Table 2

NAAQS (national ambient air quality standards) for India

Pollutant and time-weighted average	*Concentration in ambient air (µg/m³)* Industrial area	*Residential, rural, and other areas*	*Sensitive area*	*Methods of measurement*
Sulphur dioxide				
Annual average	80.0	60.00	15.00	Improved West and Gaeke method
24 hours	120.0	80.00	30.00	Ultraviolet fluorescence
Oxides of nitrogen				
Annual average	80.0	60.00	15.00	Jacob and Hochheiser modified (Na-Arsenite) method
24 hours	120.0	80.00	30.00	Gas-phase chemiluminescence
Suspended particulate matter				
Annual average	360.0	140.00	70.00	High-volume sampling (average flow rate not less than 1.1 m³ per minute)
24 hours	500.0	200.00	100.00	
Respirable particulate matter (size less than 10 µm)				
Annual average	120.0	60.00	50.00	Respirable particulate matter sampler
24 hours	150.0	100.00	75.00	
Lead				
Annual average	1.0	0.75	0.50	Atomic absorption spectrometry after sampling using EPM 2000 or an equivalent filter paper
24 hours	1.5	1.00	0.75	
* **Carbon monoxide**				
8 hours	5.0 *	2.00 *	1.00 *	Non-dispersive infrared spectroscopy
1 hour	10.0 *	4.00 *	2.00 *	
Ammonia				
Annual average	—	400 *	—	—
24 hours	—	100 *	—	—

* mg/m³

Notes

1 Annual average is annual arithmetic mean of minimum 104 measurements in a year taken twice a week at 24-hourly intervals

2 24-hourly and 8-hourly values should be met 98% of the time in a year However, 2% of the time, it may exceed but not on two consecutive days.

3. NAAQS, the levels of air quality necessary with an adequate margin of safety to protect public health, vegetation, and property

4 Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.

5. The state government/state board shall notify the sensitive and other areas in the respective states within a period of six months from the date of notification of NAAQS.

6 Standard for ammonia specified vide notification dated 14 October 1998 It does not mention about the type of areas for its applicability nor the method of measurement is being specified

Sources

1 CPCB 1994 Central Pollution Control Board Notification New Delhi Central Pollution Control Board, Ministry of Environment and Forests

2 CII 1999 Environmental legislation in India A Guide for Industry and Business New Delhi Environment Management Division, Confederation of Indian Industry

For more details, please see TEDDY ONLINE+ [Section. Environment (air general)]

Table 3

Maximum permissible limits ($\mu g/m^3$) of pollutants in the air set by WHO (World Health Organization)

Pollutant	*Time-weighted average*	*Averaging time*
Sulphur dioxide (WHO: 1979, 1987)	500	10 minutes
	350	1 hour
	100 to 150 *	24 hours
	40 to 60 *	1 year
Carbon monoxide	30	1 hour
	10	8 hours
Nitrogen dioxide (WHO: 1987, 1977)	400	1 hour
	150	24 hours
Ozone (WHO: 1987, 1978)	150 to 200	1 hour
	100 to 120	8 hours
Total SPM (suspended particulate matter)	150 to 230 *	24 hours
	60 to 90 *	1 year

* guideline values for combined exposure to sulphur dioxide and SPM (they may not apply to situations where only one of the components is present)

Source

WHO/UNEP. 1992. Urban Air Pollution in Megacities of the World. Washington, DC: World Health Organization and United Nations Environment Programme.

Table 4

Noise standards

		Limits in dB(A)	
Area code	*Category of area*	*Day-time (6 a.m. to 9 p.m.)*	*Night-time (9 p.m. to 6 a.m.)*
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D*	Silence zone	50	40

* area up to 100 m around premises such as hospitals, educational institutions, and courts

Note

The silence zones are to be declared by the competent authority. Use of vehicular horns, loudspeakers, and bursting of crackers are banned in these zones.

Source

CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 313. New Delhi. Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (noise)]

Table 5

Criteria for classification of inland surface water

Parameter	*Maximum/ minimum*	*Drinking water without conventional treatment but after disinfection*	*Outdoor bathing, organized*	*Drinking water with conventional treatment followed by disinfection*	*Propagation of wildlife and fisheries*	*Irrigation, industrial cooling, etc.*
Dissolved oxygen (mg/litre)	Minimum	6.0	5.0	4.0	4.0	—
Biological oxygen demand (mg/litre)	Minimum	2.0	3.0	3.0	—	—
Total coliform bacteria (most probable number per 100 millilitres)	Maximum	50.0	500.0	5000.0	—	—
Total dissolved solids (mg/litre)	Maximum	500.0	—	1500.0	—	2100.0
Chloride as chlorine (mg/litre)	Maximum	250.0	—	600.0	—	500.0
Colour (hazen)	Maximum	10.0	300.0	300.0	—	—
Sodium absorption ratio	Maximum	—	—	—	—	26.0
Boron (mg/litre)	Maximum	—	—	—	—	2.0
Sulphates (mg/litre)	Maximum	400.0	—	400.0	—	1000.0
Nitrates (mg/litre)	Maximum	20.0	—	50.0	—	—
Free ammonia as nitrogen (mg/litre)	Maximum	—	—	—	12.0	—
Conductivity at 25 °C (µs/cm)	Maximum	—	—	—	1.0	2.3
pH		6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.0–8.0
Arsenic (mg/litre)	Maximum	0.1	0.2	0.2	—	—
Iron (mg/litre)	Maximum	0.3	—	50.0	—	—
Fluorides (mg/litre)	Maximum	1.5	1.5	1.0	—	—
Lead (mg/litre)	Maximum	0.1	—	0.1	—	—
Copper (mg/litre)	Maximum	1.5	—	1.5	—	—
Zinc (mg/litre)	Maximum	15.0	—	15.0	—	—

Source

ISI 1982. Indian Standards (IS 2291) New Delhi. Indian Standards Institute

Table 6

Maximum permissible limits (mg/litre) for industrial effluent discharges

Parameter	*Into inland surface waters Indian Standards: 2490 (1974)*	*Into public sewers Indian Standards: 3306 (1974)*	*On land for irrigation Indian Standards: 3307 (1974)*
pH	5.5–9.0	5.5–9.0	5.5–9.0
Biological oxygen demand (for 5 days at 20 °C)	30.0	350.0	100.0
Chemical oxygen demand	250.0	—	—
Suspended solids	100.0	600.0	200.0
Total dissolved solids (inorganic)	2100.0	2100.0	2100.0
Temperature (°C)	40.0	45.0	—
Oil and grease	10.0	20.0	10.0
Phenolic compounds	1.0	5.0	—
Cyanides	0.2	2.0	0.2
Sulphides	2.0	—	—
Fluorides	2.0	15.0	—
Total residual chlorine	1.0	—	—
Pesticides	—	—	—
Arsenic	0.2	0.2	0.2
Cadmium	2.0	1.0	—
Chromium (hexavalent)	0.1	2.0	—
Copper	3.0	3.0	—
Lead	0.1	1.0	—
Mercury	0.0	0.0	—
Nickel	3.0	3.0	—
Selenium	0.1	0.1	—
Zinc	5.0	15.0	—
Chlorides	1000.0	1000.0	600.0
Boron	2.0	2.0	2.0
Sulphates	1000.0	1000.0	1000.0
Sodium (%)	—	60.0	60.0
Ammoniacal nitrogen	50.0	50.0	—
Radioactive materials			
Alpha emitters (milli curie/millilitre)	10^{-7}	10^{-7}	10^{-8}
Beta emitters (μ curie/millilitre)	10^{-6}	10^{-6}	10^{-7}

Source

CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder Volume I pp 311–312 New Delhi Central Pollution Control Board

Table 7

Effluent standards for integrated iron and steel plants

Unit and parameter	*Permissible limit (mg/litre)*
Coke oven	
By-product plant	—
pH	6.0–8.0
Suspended solids	100.0
Phenol	1.0
Cyanide	0 2
Biological oxygen demand (5 days at 20 °C)	30.0
Chemical oxygen demand	250.0
Ammoniacal nitrogen	50.0
Oil and grease	10 0
Other plants such as sintering plant, blast furnace, steel melting, and rolling mill	
pH	6.0–9.0
Suspended solids	100.0
Oil and grease	10.0

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder Volume I pp. 281–282. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 8

Effluent standards for aluminium industry

Plant	*Parameter*	*Permissible limit*
Alumina plant		
Raw material handling	Primary and secondary crusher particulate matter	150 mg/m³
Precipitation area calcination	Particulate matter	250 mg/m³
	Carbon monoxide	1% maximum
	Stack height *	
Smelter plant		
Green anode shop	Particulate matter	150 mg/m³
Anode bake oven	Particulate matter	150 mg/m³
	Total fluoride	0.3 kg/tonne of Al (aluminium)
Potroom	Particulate matter	150 mg/m³
	Total fluoride	
	Vertical stud soderberg	4 7 kg/tonne of Al produced
	Horizontal stud soderberg	6.0 kg/tonne of Al produced
	Prebacked side worked	2.5 kg/tonne of Al produced
	Prebacked centre worked	1 0 kg/tonne of Al produced
	Stack height *	

* $H = 14 Q^{03}$, where Q is the emission rate of sulphur dioxide in kg/h and H is the stack height in metres.

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder Volume I pp 284–285 New Delhi Central Pollution Control Board, Ministry of Environment and Forests 501 pp.

Table 9

Effluent standards for sugar industry

Parameter	*Permissible limit (mg/litre)* *Disposal on land*	 *Disposal in surface water*
Biological oxygen demand (5 days at 20 °C)	100	30
Suspended solids	100	30

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 267.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 10

Effluent standards for large pulp and paper industries

Capacity (tonnes a year)	*Parameter*	*Permissible limit*
Above 24000	pH	7.0–8.5
	Biological oxygen demand at 20 °C	30 mg/litre
	Chemical oxygen demand	350 mg/litre
	Suspended solids	50 mg/litre
	Total organic chloride	2 0 kg/tonne of paper produced
	Flow (total waste water discharge)	
	* Large pulp and paper	200 m^3/tonne of paper produced
	Large rayon grade newsprint	150 m^3/tonne of paper produced

* the standards with respect to total waste water discharge for large pulp and paper mills established from 1992 will meet the standards of 100 m^3/tonne of paper produced

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 296.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 11

Effluent standards (mg/litre, except for pH) for oil refinery industry

Parameter	*Permissible limit*	*Quantum (kg/thousand tonnes of crude processed)*
Oil and grease	10.0	7.00
Phenol	1.0	0.70
Sulphide	0.5	0.35
Biological oxygen demand (5 days at 20 °C)	15.0	10.50
Suspended solids	20.0	14.00
pH	—	6.00–8.50

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder Volume I p 266.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests 501 pp.

Table 12

Effluent standards (mg/litre, except for pH) for petrochemical (basic and intermediates) industry

	Parameter	*Permissible limit*
	pH	6.5–8 5
*	BOD (biological oxygen demand) (5 days at 20 °C)	50.0
†	Phenol	5.0
	Sulphide (as S)	2 0
	COD (chemical oxygen demand)	250 0
	Cyanide (as CN)	0 2
‡	Fluoride (as F)	15.0
	Total suspended solids	1000 0
	Hexavalent chromium	0.1
§	Total chromium (as Cr)	2 0

* the state board may prescribe the BOD (biological oxygen demand) value of 30 mg/litre if the recipient system so demands

† the limit for phenol shall be confirmed at the outlet of effluent treatment of phenol plant
However, at the final disposal point, the limit shall be less than 1 mg/litre

‡ the limit for fluoride shall be confirmed at the outlet of the chrome removal unit However, at the disposal point, fluoride concentration shall be lower than 5 mg/litre

§ the limits for total and hexavalent chromium shall be confirmed at the outlet of the chromate removal
This implies that in the final treated effluent total, and hexavalent chromium shall be lower than prescribed herein

Source
CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder Volume I p 286
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests 501 pp.

Table 13

Effluent standards for thermal power plants

Discharges from	*Parameter*	*Maximum limiting concentration (mg/litre) (except for pH and temperature)*
Condenser cooling waters (once through the cooling system)	pH	6.5–8.5
	Temperature	Not more than 5 °C higher than the intake water temperature
	Free available chlorine	0 5
Boiler blow-downs	Suspended solids	100
	Oil and grease	20
	Copper (total)	1
	Iron (total)	1
Cooling tower blow-downs	Free available chlorine	0 5
	Zinc	1 0
	Chromium (total)	0.2
	Phosphate	5 0
	Other corrosion inhibiting material	Limit to be established on a case-by-case basis by the Central Board in case of union territories and state board in case of states
Ash pond effluent	pH	6 5–8 5
	Suspended solids	100
	Oil and grease	20

Source
CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder Volume I p 267
New Delhi Central Pollution Control Board, Ministry of Environment and Forests. 501 pp

For more details, please see TEDDY ONLINE+ [Section: Environment (air power)]

Table 14

Maximum permissible limits (mg/m³) for emissions of particulate matter from thermal power stations

Boiler size (MW)	*Protected areas*	*Other areas*
Less than 210	150	350
210 or more	150	150

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 280. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: power)]

Table 15

Guidelines for minimum stack heights

Power generation capacity	*Stack height (m)*
Less than 200/210 MW	— *
200/210 and above to less than 500 MW	220
500 MW and above	275
Steam-generating capacities of boilers (tonnes per hour)	
Less than 2	— †
More than 2 to 5	12
More than 5 to 10	15
More than 10	18
More than 15 to 20	21
More than 20 to 25	24
More than 25 to 30	27
More than 30	30 or using formula *

using formula $H = 14 Q^{0.3}$, whichever is more, where Q is the emission rate of sulphur dioxide in kg/h and H is the stack height

2.5 times the height of the neighbouring building or 9 m, whichever is more

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 283. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 16

Indian emission standards and proposed World Bank emission guidelines for thermal power plants

Parameters	*Indian emission standards*			*World Bank proposed emission guidelines*		
	Capacity	*Fuels*	*Standards*	*Standards mg/m³*	*Control options*	*Main concerns*
Particulate matter	Less than 200/210 MW		350 mg/Nm³	50	Existing technologies (ESP or bag houses) to achieve emission below 50 mg/m³	Fine particulate PM$_{10}$ and PM$_{2.5}$
	200/210 MW and above		150 mg/Nm³	If it is not achievable, 99 9% removal efficiency for all the plants in airsheds with good air quality	Coal cleaning to reduce mass loadings and improve boiler efficiency and reduce boiler maintenance	
Sulphur dioxide	Less than 200 MW		H - 14 (Q)$^{0 8}$ metres, Q-emission rate of sulphur dioxide in kg/h	2000 Maximum level 0 2 TPD per MW up to 500 MW plus	Use of gas or low sulphur fuels Furnace sorbent injection (30%–60% removal)	Local impacts of sulphur dioxide and sulphates on health Long-range transport acidification and visibility
	200 MW and less than 500 MW		220 m stack height	0 1 TPD per MW for each additional MW over 500 MW	Dust injection, dry or wet scrubbers (upto 95% removal), or fluidized bed combustion (up to 95% removal)	
	500 MW and above		275 m stack height	but not more than 500 TPD for any plant		
Nitrogen oxides	All existing units	Natural gas/ Naphtha	150 at 15% excess oxygen	750 (365 PPM) (coal)	Low nitrogen oxides burners with or without other combustion modifications	Contribution to creation of ground level ozone, acidification and visibility impacts
				460 (225 PPM) (oil)	Reburning, water/steam injection	
	New units (effective from 1 January 1998) 400 MW and above	Natural gas Naphtha	50 100	320 (155 PPM) (gas)	Selective catalytic or non catalytic reduction	
	100–400 MW	Natural gas Naphtha	75 100			
	< 100 MW	Natural gas Naphtha	100			

PPM - parts per million TPD - tonnes per day

Note

The range of control of sulphur dioxide is greater because of large difference in the sulphur content of different fuels and in control costs. In general, for low sulphur (< 1%S), high calorific fuels, specific control may not be required

Coal cleaning (when feasible), sorbent injection or fluidized bed combustion may be adequate for medium sulphur fuels (1-3%S) FGD may be considered for high sulphur fuels (> 3%S)

The technology choice depends on a benefit cost analysis of the environmental performance for different fuels and the cost of controls

Sources

1 MoEF Ministry of Environment and Forests

2 TERI 1998 *Review of the environmental guidelines prepared by the World Bank for new thermal power plants* Final report submitted to the World Bank New Delhi Tata Energy Research Institute

Table 17

Maximum permissible limits (mg/m^3) for emissions from integrated iron and steel plants

Pollutant and sources	*Emission limit*
Particulate matter	
Sintering plant	150
Coke oven	50
Steel making	—
During normal operation	150
During oxygen lancing	400
Carbon monoxide	
Coke oven (kilogram per tonne of coke produced)	3

Source
CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 279. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 18

Maximum permissible limits (mg/m^3) for emissions of particulate matter from cement plants

Capacity (tonnes per day)	*Protected areas*	*Other areas*
200	250	400
Greater than 200	150	250

Source
CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 270. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 19

Maximum permissible limits (mg/m^3) for emissions from fertilizer plants

Product	*Pollutant*	*Emission limit*
Urea		
Pricing tower	Particulates	50
Phosphatic fertilizer		
Acidification of rock phosphate	Fluorides	25
Granulation, mixing, and grinding of rock phosphate	Particulates	150

Source
CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 278 New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 20

Maximum permissible limits for emissions of sulphur dioxide from oil refineries

Process	*Emission limit (kilogram per tonne of feed)* *
Atmospheric and vacuum distillation	0.25
Catalytic cracker	2.50
Sulphur recovery unit	120.00

* indicates the feed for the specific part of the process under consideration.

Source

CPCB. 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 284.
New Delhi· Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: refineries)]

Table 21

Maximum permissible limits (mg/m^3) for emissions of particulate matter from calcium carbide plants

Source	*Emission limit*
Kiln	250
Arc furnace	150

Source

CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p 278.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 22

Maximum permissible limits for emissions from copper, lead, and zinc smelting units

Pollutant	*Source*	*Emission limit*
Particulate matter	Concentrator	150 (mg/m^3)
* Oxides of sulphur	Smelter and convertor	4 kilograms per tonne of concentrated (100%) acid produced

* off-gases must be utilized for sulphuric acid manufacturing.

Source

CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 279
New Delhi Central Pollution Control Board, Ministry of Environment and Forests. 501 pp

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 23

Maximum permissible limits (mg/m³) for emissions of particulates from carbon black industry

Pollutant	*Emission limit*
Particulate matter	150

Source

CPCB. 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 279. New Delhi Central Pollution Control Board, Ministry of Environment and Forests 501 pp

For more details, please see TEDDY ONLINE + [Section: Environment (air: industry)]

Table 24

Maximum permissible limits (mg/m³) for emissions of particulate matter from aluminium industry

Process	*Emission limit*
Calcination	250
Smelting	150

Source

CPCB 1998 Pollution Control Acts, Rules, and Notifications issued thereunder Volume I p 278 New Delhi· Central Pollution Control Board, Ministry of Environment and Forests 501 pp

For more details, please see TEDDY ONLINE+ [Section Environment (air: industry)]

Table 25

Emission factors (g/km) for different vehicles

Vehicle	*Carbon monoxide*	*Hydrocarbons*	*Oxides of nitrogen*	*Sulphur dioxide*	*Lead*	*Total suspended particulate matter*
Two-wheeler	8.30	5.18	0.10	0.05	0.05	0.05
Cars (petrol)	(28.9**)2.6*	6.2–0.3	2.7–0.6	0.22–0.14	0.01	0.33–0.08
Three-wheeler	12.25	7.65	0.10	0.10	0.01	0.50
Cars (diesel)	1.10	0.28	1.40	0.93	—	0.60
Bus	12.70	2.10	21.00	2.50	—	2.00
Truck	12.70	2.10	21.00	2.50	—	2.00
Light commercial vehicle	5.39	0.66	9.34	0.90	—	0.83

new cars with catalytic convertors

pre-1984 model cars

Source

IIP 1985 State of Art Report on Vehicle Emissions Dehra Dun Indian Institute of Petroleum

For more details, please see TEDDY ONLINE+ [Section. Environment (air: transport)]

Table 26

Emission limits (%) for petrol-driven vehicles (idling condition)

Parameter	*Type of vehicle*	*Limit (% by volume)*
Carbon monoxide	Four-wheelers	3.0
	Two- and three-wheelers	4.5

Source

CPCB. 1998. Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p. 314. New Delhi Central Pollution Control Board, Ministry of Environment and Forests 501 pp.

Table 27

Emission limits for diesel vehicles

		Maximum smoke density	
Method of test	*Light absorption coefficient (millilitre)*	*Bosch units*	*Hartridge units*
Full load at a speed of 60%–70% of maximum engine-rated speed specified by the manufacturer	3.1	5.2	75
Free acceleration	2.3	—	65

Source

CPCB. 1998 Pollution Control Acts, Rules, and Notifications issued thereunder. Volume I p 314. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp

Table 28

Mass emission standards (g/km) for petrol driven vehicles

		1 April 1996		*1 April 2000*	*1 April 2005*
	1 April 1991	*without catalytic converter*	*with catalytic converter*	*Euro I Norm*	*Euro I Norm*
Four-wheeled passenger vehicle					
Carbon monoxide	14.3–27.1	8 68–12.40	4.34–6.20	2.72	2.2
Hydrocarbon	2.0–2.9	—	—	—	—
Hydrocarbon and oxides of nitrogen	—	3.00–4.36	1 50–2 18	0.97	0.5

		1 April 1996	*1 April 1998*	*1 April 2000*
	1 April 1991	*Indian driving cycle with warm start*	*Indian driving cycle with cold start*	*Indian driving cycle with cold start*
Two wheelers				
Carbon monoxide	12–30	4.5	4.5	2.0
Hydrocarbon	8–12	—	—	—
Hydrocarbon and oxides of nitrogen	—	3.6	3.6	2.0

		1 April 1996	*1 April 1998*	*1 April 2000*
	1 April 1991	*Indian driving cycle with warm start*	*Indian driving cycle with cold start*	*Indian driving cycle with cold start*
Three wheelers				
Carbon monoxide	12–30	6.75	6.75	4.0
Hydrocarbon	8–12	—	—	—
Hydrocarbon and oxides of nitrogen	—	5.40	5.40	2.0

Source

Compiled by TERI from Fuel and Vehicular Technology, Association of Indian Automobile Manufacturers, New Delhi. 1999

Table 29

Mass emission standards (g/kWh) for diesel-driven vehicles

	1 April 1992	*1 April 1996*	*1 April 2000*	*Euro II*	*Euro III*
Gross vehicle weight > 3.5 tonnes					
Carbon monoxide	14.0	11.2	4.5	4.0	2.0
Hydrocarbon	3.5	2.4	1.1	1.1	0.6
Oxides of nitrogen	18.0	14.4	8.0	7.0	5.0
Particulate matter for > 85 kW	—	—	0.4	0.2	0.1
Particulate matter for < 85 kW	—	—	0.6	0.2	0.1

	1 April 1992 (g/kWh)	*1 April 1996 (g/km)*	*1 April 2000 (g/km)*
Gross vehicle weight < 3.5 tonnes			
Carbon monoxide	14.0	5.0–9.0	2.72–6.90
Hydrocarbon	3.5	—	—
Oxides of nitrogen	18.0	2.0–4.0	0.97–1.70
Particulate matter	—	—	0.14–0.25

Source

Compiled by TERI from Fuel and Vehicular Technology,
Association of Indian Automobile Manufacturers, New Delhi. 1999.

Table 30

Cities with highly and critically polluted air quality levels

		1994					
		Sulphur dioxide		*Oxides of nitrogen*		*Suspended particulate matter*	
State/Union territory	City	*Industrial*	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*
Andhra Pradesh	Hyderabad	L	L	L	M	—	—
	Vishakhapatnam	—	—	—	—	—	—
Bihar	Dhanbad	—	M	—	M	—	C
	Jharia	M	—	M	—	H	—
	Patna	—	L	—	L	C	—
	Sindri	L	—	M	—	M	—
Delhi		L	M	L	H	H	C
Gujarat	Ahmedabad	L	H	L	L	M	C
	Ankleshwar	H	H	M	L	M	C
	Baroda	M	M	L	L	M	C
	Rajkot	L	L	L	L	C	C
	Surat	M	M	L	L	H	C
	Vapi	—	L	—	M	—	H
Goa	Ponda	—	L	—	L	—	H
	Vasco	L	—	L	—	L	—
Himachal Pradesh	Damtal	—	—	—	—	—	C
	Parwanoo	—	—	—	—	—	—
	Shimla	H	—	—	—	—	—
Haryana	Dharunhera	—	M	—	M	—	C
	Faridabad	—	M	—	L	—	C
	Yamuna Nagar	L	—	L	—	—	—
Kerala	Kottayam	—	L	—	L	—	H
Maharashtra	Mumbai	M	L	M	M	—	—
	Nagpur	L	L	L	L	L	C
	Pune	—	—	—	—	—	—
Madhya Pradesh	Bhilai	—	—	—	—	—	—
	Bhopal	—	—	—	—	—	—
	Indore	—	—	—	—	—	—
	Jabalpur	—	C	—	—	—	—
	Korba	—	—	—	—	—	—
	Nagda	—	—	—	—	—	—
	Raipur	—	—	—	—	—	—
	Satna	—	—	—	—	—	—
Orissa	Angul	L	—	L	—	L	H
	Rourkela	M	L	M	L	M	H
Punjab	Jalandhar	—	—	—	—	—	—
	Ludhiana	—	—	—	—	—	—
Rajasthan	Alwar	C	—	L	—	H	C
	Jaipur	L	L	M	C	—	—
	Kota	L	L	M	H	H	H
Uttar Pradesh	Dehra Dun	L	L	L	L	H	C
	Gajroula	H	—	M	—	C	—
	Kanpur	L	L	L	L	—	C
	Lucknow	L	—	L	—	H	—
West Bengal	Calcutta	M	M	L	M	H	C
	Howrah	L	C	C	C	L	C
Chandigarh		L	L	L	L	M	H
Pondicherry		M	L	M	M	M	H

Notes
L - low, M - moderate, H - high, C - critical
L – 0–40 and 0–180 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in industrial areas
L – 0–30 and 0–70 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in residential areas
M – 40–80 and 180–360 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in industrial areas
M – 30–60 and 70–140 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in residential areas
H – 80–120 and 360–540 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in industrial areas
H – 60–90 and 140–210 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in residential areas
C – >120 and >540 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in industrial areas
C – >90 and >210 mg/m^3 for sulphur dioxide and nitrogen dioxide and SPM, respectively in residential areas

Source
CPCB 1999 Ambient Air Quality http.//www nic in/enfor/cpcb/aaq/ Accessed on 17 May 1999
Central Pollution Control Board, Ministry of Environment and Forests

1995						*1996*					
Sulphur dioxide		*Oxides of nitrogen*		*Suspended particulate matter*		*Sulphur dioxide*		*Oxides of nitrogen*		*Suspended particulate matter*	
Industrial	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*
L	L	M	M	M	H	L	L	M	L	—	—
L	L	—	—	—	—	L	L	M	H	L	C
—	M	—	M	—	C	—	M	—	M	—	C
M	—	M	—	H	—	M	—	M	—	H	—
—	L	—	L	—	C	—	M	—	M	—	C
L	—	M	—	M	—	M	—	M	—	M	—
L	M	M	M	H	C	L	L	M	H	H	C
L	H	L	L	M	C	L	M	L	L	M	C
H	H	L	L	M	C	H	H	L	M	L	H
M	H	L	L	M	C	M	H	L	L	M	C
L	L	L	L	C	C	L	L	L	L	C	C
H	C	L	M	M	C	M	H	L	L	M	C
—	M	—	M	—	H	M	M	M	L	M	H
—	L	—	L	—	H	—	—	—	—	—	M
L	—	L	—	L	—	L	—	L	L	—	—
—	L	—	L	—	C	—	L	—	L	—	H
—	—	L	L	M	C	L	L	L	L	L	H
—	L	—	L	—	H	—	L	—	L	—	M
—	—	—	—	—	—	—	—	—	—	—	—
L	M	L	L	M	C	—	M	—	L	—	C
L	—	L	—	—	—	L	—	L	—	M	—
—	L	—	L	—	H	L	—	L	—	L	—
M	L	L	M	—	C	L	L	L	M	—	—
L	L	L	L	M	C	L	L	L	L	L	C
L	L	L	L	M	M	—	—	—	—	—	—
L	L	L	M	H	C	L	L	L	L	H	C
L	L	L	L	M	C	L	L	L	M	M	C
L	L	L	L	H	C	L	L	L	L	H	C
—	L	—	H	—	H	—	L	—	L	—	H
—	—	—	—	—	C	—	L	—	L	—	C
M	M	L	M	L	C	M	H	M	L	M	H
L	L	L	L	M	C	L	L	L	L	M	C
L	L	L	L	M	C	L	L	L	L	M	H
—	—	—	—	—	—	—	L	—	L	—	C
M	L	L	L	M	H	L	L	L	L	M	C
—	—	—	—	—	—	—	L	—	M	—	C
—	—	—	—	—	—	L	L	M	L	H	C
L	L	M	H	H	C	L	L	H	H	H	C
L	L	L	M	M	C	L	L	M	L	—	C
L	L	M	H	M	H	L	L	M	L	M	H
L	L	L	L	H	C	—	—	—	—	—	—
—	—	—	—	—	—	L	—	L	—	H	C
L	L	L	L	—	C	L	L	L	L	H	C
L	L	L	L	H	C	—	M	—	M	—	C
M	M	L	M	H	C	L	L	L	M	H	—
L	C	C	C	M	C	—	C	—	C	M	C
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—

Table 31

Categories of biomedical waste

Option	*Waste category*	*Treatment and disposal*
Category No. 1	**Human anatomical waste** (human tissues, organs, body parts)	‡ Incineration § Deep burial
Category No. 2	**Animal waste** (animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	‡ Incineration § Deep burial
Category No. 3	**Microbiology and biotechnology waste** (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local autoclaving/micro-waving/ ‡ incineration
Category No. 4	**Waste sharps** (needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps)	* Disinfection (chemical treatment autoclaving/micro-waving and † mutilation/shredding
Category No. 5	**Discarded medicines and cytotoxic drugs** (wastes comprising of outdated, contaminated and discarded medicines)	‡ Incineration/destruction and drugs disposal in secured landfills
Category No 6	**Solid waste** (items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	‡ Incineration/autoclaving/ micro waving
Category No 7	**Solid waste** (waste generated from disposal items other than waste sharps such as tubings, catheters, intravenous sets, etc.)	* Disinfection by chemical treatment autoclaving/micro waving and mutilation/ † shredding
Category No. 8	**Liquid waste** (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	* Disinfection by chemical treatment and discharge into drains
Category No 9	**Incineration ash** (ash from incineration of any biomedical waste)	Disposal in municipal landfill
Category No 10	**Chemical waste** (chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	* Chemical treatment and discharge into drains for liquids and secured landfill for solids

* chemical treatment using at least one per cent hypochlorite solution or any other equivalent chemical reagen. It must be ensured that chemical treatment ensures disinfection

† Multilation/shredding must be such so as to prevent unauthorized reuse

‡ There will be no chemical pretreatment before incineration Chlorinated plastics shall not be incinerated

§ Deep burial shall be an option available only in towns with population less than half a million and in rural areas

Source

MoEF November 1998 Enviro News New Delhi: Ministry of Environment and Forests

Table 32

Average noise levels in dB(A) various metropolitan cities

Metropolitan cities	*Day/night*	*Industrial area*	*Commercial area*	*Residential area*	*Silence area*
Calcutta	Day	78	82	79	79
	Night	67	75	65	65
Mumbai	Day	76	75	70	66
	Night	65	66	62	52
Chennai	Day	71	78	66	63
	Night	66	71	48	49
Bangalore	Day	78	76	67	67
	Night	53	57	50	—

Source

MoEF. 1995. State of the Environment. New Delhi: Ministry of Environment and Forests.

Table 33

Pollution control status of 17 categories of industries: 31 March 1996

Industry	*Total no. of units*	*Closed (no.)*	*Status (no. of units)* Having adequate facilities to comply with the standards	*Status (no. of units)* Not having adequate facilities to comply with the standards
Aluminium	7	1	5	1
Caustic Soda	25	—	25	—
Cement	116	4	103	9
Copper	2	—	—	2
Distillery	177	16	117	44
Dyes & Dye intermediates	64	3	55	6
Fertilizer	110	8	97	5
Iron and steel	8	—	2	6
Leather	70	8	59	3
Pesticides	71	6	63	2
Petrochemicals	49	—	49	—
Pharmaceuticals	251	25	224	2
Pulp and paper	96	15	62	18
Refinery	12	—	10	2
Sugar	392	23	296	73
Thermal power plants	97	2	65	30
Zinc	4	—	4	—
Total	1551	111	1237	203

Source

CPCB. 1997. Annual Report 1996/97. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 34

Summary status of pollution contract in 17 categories of industries in states and union territories: 31 March 1999

State/union territory	*Total no. of units belonging to 17 categories*	*Closed (no.)*	*Having adequate facilities to comply with the standards (no.)*	*Not having adequate facilities to comply with the standards (no.)*
State				
Andhra Pradesh	173	29	142	2
Assam	15	—	11	4
Bihar	62	14	35	13
Delhi	5	—	2	3
Goa	6	—	6	—
Gujarat	177	3	167	7
Haryana	43	3	32	8
Himachal Pradesh	9	—	9	—
Jammu and Kashmir	8	3	1	4
Karnataka	85	8	68	9
Kerala	28	5	20	3
Madhya Pradesh	78	5	59	14
Maharashtra	335	21	296	18
Meghalaya	1	—	—	1
Orissa	23	1	14	8
Punjab	45	4	25	16
Rajasthan	49	6	42	1
Sikkim	1	—	—	1
Tamil Nadu	119	2	114	3
Uttar Pradesh	224	16	189	19
West Bengal	58	14	32	12
Union territory				
Chandigarh	1	—	1	—
Pondicherry	6	1	4	1
Total	**1551**	**135**	**1269**	**147**

Note

There are no industries belonging to the 17 categories existing (pre-1991) in Arunachal Pradesh, Manipur, Mizoram, Nagaland, Tripura, Andaman and Nicobar Islands, Lakshadweep and Daman, Diu, Dadra and Nagar Haveli

Source

MoEF. 1999. Annual Report 1998/99. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 35

List of polluted river stretches in India

River	Polluted stretch	Desired	Existing class	Critical parameters	Possible sources of pollution
Sabarmati	Immediate upstream of Ahmedabad	B	E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ahmedabad
	Sabarmati Ashram to Vautha	D	E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ahmedabad
Subernarekha	Hatia Dam to Baharagora	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ranchi and Jamshedpur
Godavari	Downstream of Nasik to Nanded	C	Partly D and partly E	BOD	Waste from sugar, distillery, and food-processing industries
	City limit to Nasik and Nanded	B	Partly D and partly E	BOD	Waste from sugar, distillery, and food-processing industries
Krishna	Karad to Sangli	C	Partly D and partly E	BOD	Waste from sugar and distillery industries
Indus (tributaries, Sutlej)	Downstream of Ludhiana to Harike	C	Partly D and partly E	Dissolved oxygen, BOD	Industrial waste from hosieries, tanneries, electroplating, and engineering
	Downstream of Nangal to Anandpur	C	E	Ammonia	Wastes of fertilizer, chlor alkali, and paper mills from Nangal
Ganga (Tributaries)					
Yamuna	Delhi to confluence with Chambal	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Delhi, Mathura, and Agra
	In the city limits of Delhi, Mathura	B	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Delhi, Mathura, and Agra
Hindon	Saharanpur to confluence with Yamuna	D	E	Dissolved oxygen, BOD, coliforms	Industrial and domestic waste from Saharanpur and Ghaziabad
Chambal	Downstream of Nagda and downstream of Kota	C	Partly D and partly E	BOD, dissolved oxygen	Domestic and industrial waste from Nagda and Kota
Damodar	Downstream of Dhanbad to Haldia	C	Partly D and partly E	BOD, toxic	Industrial waste from Dhanbad,Durgapur, Asansol, Haldia, and Burnpur
Gomti	Lucknow to confluence with Ganga	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Industrial waste from distilleries and domestic waste from Lucknow
Kali	Downstream of Modinagar to confluence with Ganga	C	Partly D and partly E	BOD, coliforms	Industrial and domestic waste from Modinagar

B Outdoor bathing organized
C Drinking water source with conventional treatment followed by disinfection
D Propagation of wildlife and fisheries
E: Irrigation, industrial cooling, etc
BOD Biological oxygen demand

Source
MoEF 1993 National Environment Programme. p 167 New Delhi Ministry of Environment and Forests 220 pp

Table 36

GPIs (grossly polluting industries) discharging into water course in states and union territories

State/union territory	*Number of GPIs*
State	
Andhra Pradesh	64
Assam	12
Bihar	68
Goa	1
Gujarat	19
Haryana	128
Himachal Pradesh	51
Jammu and Kashmir	—
Karnataka	5
Kerala	12
Madhya Pradesh	16
Maharashtra	—
Nagaland	—
Orissa	25
Punjab	20
Rajasthan	14
Tamil Nadu	714
Delhi	7
Uttar Pradesh	372
West Bengal	—
Union territory	
Andaman and Nicobar Islands	—
Daman, Diu, Dadra and Nagar Haveli	—
Lakshadweep	—
Pondicherry	4
Total	**1532**

Note

There are no GPIs discharging into water course in Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim, Tripura, and Chandigarh.

Source

CPCB. 1997 Annual Report 1996/97. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 37

Potable water quality standards as recommended by the WHO (mg/litre)

Parameter	*Class A: maximum permissible limit*	*Class B: maximum allowable limit*	*Indian Standards: 10 500 (1991)*
Physical parameters			
Colour (hazen)	5.0	25.0	5.0
Turbidity (NTU)	5.0	25.0	5.0
pH	7.0–8.5	6.5–9.2	6.5–8.5
Temperature (°C)	—	—	—
Conductivity (mho/cm)	—	—	—
Total dissolved solids	—	—	—
Total suspended solids	—	—	—
Total solids	500.0	1500.0	500.0
Chemical parameters			
Total hardness	—	—	300.0
Calcium as calcium carbonate	175.0	500.0	75.0
Magnesium as calcium carbonate	215.0	650.0	30.0
Acidity	—	—	—
Alkalinity as calcium carbonate	—	—	200.0
Bicarbonate as calcium carbonate	—	—	—
Carbonate as calcium carbonate	—	—	—
Hydroxide as calcium carbonate	—	—	—
Chlorides as chlorine	—	—	250.0
Total residual chlorine	—	—	—
Sulphates	200.0	400.0	200.0
Fluorides	0.5	1.0–1.5	1.0
Phenol	0.0	0.0	0.0
Manganese	0.1	0.5	0.1
Silica	—	—	—
Sodium	—	—	—
Potassium	—	—	—
Organic and nutrient parameters			
Dissolved oxygen	—	—	—
Biological oxygen demand	—	—	—
Chemical oxygen demand	—	—	—
Phosphates	—	—	—
Mercury	—	—	—
Oil and grease	—	—	—
Ammoniacal nitrogen	—	—	—
Nitrates	—	50–100	45.0
Nitrites	—	—	—
Heavy metals			
Iron	0.3	1.0	0.3
Chromium	—	0.1	0.1
Boron	—	—	1.0
Zinc	—	—	5.0
Copper	1.0	1.5	1.5
Lead	—	0.1	0.1

Sources

1. WHO.1986. WHO Handbook. Geneva: World Health Organization.
2. ISI. 1991. Indian Standards (IS: 10 500). New Delhi: Indian Standards Institute

Table 38

MSW (municipal solid waste) generation (kilogram per capita per day)

Name of the city	*1971–73*	*1986/87*	*1994/95*
Ahmedabad	0.24	—	0.56
Ajmer	0.24	0.44	—
Allahabad	0.2	0.5	—
Aurangabad	0.42	0.67	—
Bangalore	0.32	—	0.48
Baroda	0.29	—	0.39
Bhopal	0.26	—	0.51
Bikaner	0.29	—	—
Calcutta	0.5	—	0.4
Chandigarh	0.36	—	—
Chennai	0.32	—	0.66
Coimbatore	0.31	—	0.43
Delhi	0.21	—	0.48
Gorakhpur	0.21	0.64	—
Guwahati	0.24	—	—
Gwalior	0.27	—	—
Howrah	0.59	—	—
Hyderabad	0.33	—	0.4
Jabalpur	0.3	—	—
Jaipur	0.28	—	0.4
Jodhpur	0.2	0.45	—
Kanpur	0.55	—	0.64
Kochi	—	0.27	0.52
Kota	0.25	0.4	—
Kozhikode	0.15	0.16	—
Kurnool	0.2	—	—
Lucknow	—	—	0.62
Ludhiana	—	0.4	0.4
Madurai	0.38	—	0.4
Mumbai	0.49	—	0.44
Nagpur	0.22	—	0.27
Patna	0.48	—	0.36
Pune	0.24	—	0.31
Raipur	0.32	0.23	—
Rajkot	0.07	0.21	—
Sangli	0.23	0.3	—
Surat	0.15	—	0.6
Tatanagar	0.45	—	—
Thane	0.23	—	—
Tiruchirapalli	0.21	—	—
Thiruvananthapuram	0.12	0.34	—
Udaipur	0.14	—	—
Varanasi	—	—	0.4
Vijayawada	0.17	0.44	—
Vishakhapatnam	—	0.31	0.4

Sources

1 INSDOC 1983. Solid Waste Management in Developing Countries. New Delhi: Indian National Scientific Documentation Centre.

2 NIUA 1989 Upgrading Municipal Services Norms and Financial Implications. New Delhi: National Institute of Urban Affairs

Table 39 A

Characteristics of municipal solid waste (%) on weight basis: 1971 to 1973

Name of the city	*Paper*	*Plastics*	*Rags*	*Metals*	*Glass*	*Total compostable matter*
Ahmedabad	3.02	0.84	4.11	0.42	0.23	49.30
Ajmer	1.44	1.02	3.28	0.31	0.40	38.15
Allahabad	3.82	8.69	2.61	0.56	0.39	44.50
Aurangabad	4.51	0.28	3.36	0.52	0.67	36.30
Bangalore	1.91	0.32	0.75	0.32	0.21	53.83
Baroda	4.78	0.29	3.32	0.60	0.25	39.25
Bhopal	7.71	0.55	5.38	0.56	0.75	38.67
Bikaner	1.03	0.52	3.59	0.14	0.53	14.52
Calcutta	3.18	0.65	3.60	0.66	0.38	40.38
Chandigarh	6.17	8.33	5.24	0.22	0.21	34.74
Chennai	7.85	0.88	4.85	0.95	0.97	47.97
Coimbatore	3.08	0.13	4.24	0.54	0.40	35.24
Delhi	6.29	0.85	4.70	1.21	0.57	35.42
Gorakhpur	1.97	0.62	3.68	0.31	0.18	34.92
Guwahati	3.46	0.18	0.29	0.68	0.28	50.59
Gwalior	4.58	0.65	2.02	0.57	0.38	30.03
Howrah	4.62	0.71	2.75	0.16	0.29	34.99
Hyderabad	4.81	0.84	3.16	1.23	0.93	39.46
Indore	—	—	—	—	—	—
Jabalpur	2.01	0.69	1.68	0.39	0.36	39.87
Jaipur	3.03	0.80	5.98	0.61	0.39	25.89
Jodhpur	1.43	0.31	3.32	0.21	0.15	19.81
Kanpur	2.97	0.63	2.77	0.39	0.38	41.09
Kochi	—	—	—	—	—	—
Kota	1.09	0.27	2.70	1.13	0.22	48.76
Kozhikode	6.03	1.75	2.02	0.38	0.06	66.05
Kurnool	1.07	0.28	1.18	0.24	0.08	40.57
Lucknow	—	—	—	—	—	—
Ludhiana	—	—	—	—	—	—
Madurai	7.81	1.44	4.23	0.70	0.52	26.51
Mumbai	4.89	2.92	2.48	2.46	0.72	59.78
Nagpur	3.51	0.39	4.07	0.65	0.58	41.79
Patna	3.00	0.20	3.16	0.27	0.15	23.24
Pune	8.74	0.72	1.63	—	0.58	67.64
Raipur	1.83	0.66	1.31	0.44	0.23	38.44
Rajkot	1.44	0.53	1.35	0.50	0.14	55.38
Sangli	3.04	0.35	2.13	0.21	0.37	51.24
Surat	3.03	1.01	2.22	0.37	0.28	44.26
Tatanagar	3.48	0.45	2.43	0.45	0.33	27.38
Thane	5.50	1.00	2.25	0.30	0.25	53.00
Tiruchirapalli	5.57	1.62	6.36	0.29	1.28	45.99
Thiruvananthapuram	3.62	0.93	1 43	0.38	0.14	71.78
Udaipur	2.38	0 28	3.18	0.16	0.57	31.03
Varanasi	—	—	—	—	—	—
Vijayawada	—	—	—	0.14	0.27	31.94
Vishakhapatnam	—	—	—	—	—	—

Sources

1 INSDOC. 1983. Solid Waste Management in Developing Countries New Delhi: Indian National Scientific Documentation Centre.

2 EPTRI. 1995 Status of Solid Waste Disposal in Metropolis. Hyderabad: Environmental Protection Research and Training Institute.

Table 39 B

Characteristics of municipal solid waste (%) on weight basis: 1995

Name of the city	*Paper*	*Plastics*	*Rags*	*Metals*	*Glass*	*Total compostable matter*
Ahmedabad	6.00	3.00	1.00	—	—	40.00
Ajmer	—	—	—	—	—	—
Allahabad	—	—	—	—	—	—
Aurangabad	—	—	—	—	—	—
Bangalore	8.00	6.00	5.00	3.00	6.00	45.00
Baroda	4.00	7.00	—	—	—	40.00
Bhopal	10.00	2.00	5.00		1.00	45.00
Bikaner	—	—	—	—	—	—
Calcutta	10.00	8.00	3.00	—	3.00	40.00
Chandigarh	—	—	—	—	—	—
Chennai	10.00	3.00	5.00	—	—	44.00
Coimbatore	5.00	1.00	9.00	—	—	35.00
Delhi	6.60	1.50	4.00	2.50	1.20	31.78
Gorakhpur	—	—	—	—	—	—
Guwahati	—	—	—	—	—	—
Gwalior	—	—	—	—	—	—
Howrah	—	—	—	—	—	—
Hyderabad	7.00	1.30	1.70	—	—	40.00
Indore	5.00	1.00	2.00	—	—	43.00
Jabalpur	—	—	—	—	—	—
Jaipur	6.00	1.00	2.00	—	2.00	42.00
Jodhpur				—	—	—
Kanpur	5.00	1.50	1.00	—	—	40.00
Kochi	4.90	1.10	—	—	—	58.00
Kota	—	—	—	—	—	—
Kozhikode	—	—	—	—	—	—
Kurnool	—	—	—	—	—	—
Lucknow	4.00	4.00	2.00	1.00	—	40.00
Ludhiana	3.00	3.00	5.00	—	—	40.00
Madurai	—	—	—	—	—	—
Mumbai	10.00	2.00	3.60	—	0.20	40.00
Nagpur	4.50	1.25	7.00	0.35	1.20	30.40
Patna	4.00	6.00	5.00	1.00	2.00	45.00
Pune	5.00	5.00	—	—	10.00	55.00
Raipur	—	—	—	—	—	—
Rajkot	—	—	—	—	—	—
Sangli	—	—	—	—	—	—
Surat	4.00	3.00	5.00	—	3.00	40.00
Tatanagar	—	—	—	—	—	—
Thane	—	—	—	—	—	—
Tiruchirapalli	—	—	—	—	—	—
Thiruvananthapuram	—	—	—	—	—	—
Udaipur	—	—	—	—	—	—
Varanasi	3.00	10.00	4.00	—	—	48.00
Vijayawada	—	—	—	—	—	—
Vishakhapatnam	3.00	5.00	2.00	—	5.00	35.00

Sources

1 INSDOC 1983 Solid Waste Management in Developing Countries. New Delhi. Indian National Scientific Documentation Centre.

2 EPTRI 1995 Status of Solid Waste Disposal in Metropolis. Hyderabad: Environmental Protection Research and Training Institute.

Table 40

Industrial solid wastes in India (million tonnes a year)

Wastes	*1985*	*1995* †
Flyash	19.0	30.0
Blast furnace slag	7.5	35.0
By-product gypsum	4.5	4.5
Red mud	1.5	3.0

also includes steel slag

Sources

1. MoEF. 1990. Industrial Waste Management. p 4. New Delhi. Ministry of Environment and Forests. 45 pp.
2. CRI. 1985 New Delhi: Cement Research Institute

Table 41

Mining waste (coal overburden removal) in the mechanized opencast mines (million cubic metre) in the Coal India Limited

Company	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*
Eastern Coalfields Ltd	2.5	8.4	16.8	20.7	16.5	20.1
Bharat Coking coal Ltd	0.7	4.6	16.3	28.4	31.0	33.7
Central Coalfields Ltd	10.8	32.8	32.4	48.4	52.1	52.2
Northern Coalfields Ltd	—	—	28.0	89.4	89.1	83.0
Western Coalfields Ltd	7.3	16.9	22.9	35.7	41.3	44.8
South-Eastern Coalfields Ltd	—	—	30.1	60.2	65.4	48.2
Mahanadi Coalfields Ltd	—	—	—	—	—	23.6
North-Eastern Coalfields Ltd	—	—	2.9	1.1	3.8	4.0
Total	**21.3**	**62.6**	**149.5**	**284.0**	**299.2**	**309.6**

Source

CIL. 1993. Operational Statistics. p. 43. Calcutta: Coal India Limited

Table 42

All-India distribution of deaths due to 10 selected diseases

Disease	*1988*	*1989*
Asthma and bronchitis	2097	1885
Heart attack	1261	1236
Pneumonia	1204	1190
Tuberculosis	1222	1106
Cancer	654	685
Anaemia	697	677
Vehicular accidents	—	446
Gastroenteritis	512	344
Typhoid	436	339
Acute abdomen	334	334
Dysentery	321	—
All causes	22950	21409

Source

CSO 1998 Proceedings of the National Workshop on Environment Statistics. p 45 New Delhi Central Statistical Organization, Department of Statistics, Ministry of Planning and Programme Implementation, Government of India

Table 43

Emission factors (g/kg) from cooking stoves for various fuel–stove combinations

Fuel and pollutant	*Conventional metal*	*Improved metal*	*Improved mud*
Total suspended particulates			
Fuelwood	1.3–2.7	1.1–3.8	1.8–2.1
Crop residues	2.1–5.0	2.1–12.0	3.5
Dung cakes	4.1–5.3	4.2–7.8	7.4
Carbon monoxide			
Fuelwood	13.0–22 0	25 0–62.0	32.0–48.0
Crop residues	20 0–39 0	23.0–114 0	48.0
Dung cakes	11 0–16.0	34 0–67.0	46.0

Source

Ahuja D R et al 1987 Environmental Performance of Cookstoves in regard to Thermal Efficiency and Emissions from Combustion Submitted to the Ministry of Environment and Forests New Delhi Tata Energy Research Institute 131 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: domestic)]

Table 44

Concentration of pollutants as a result of burning biofuels

	Total suspended particulate matter (mg/m³)		*Carbon monoxide (parts per million)*	
Location and type of stove	*Sample size (number)*	*Average*	*Sample size (number)*	*Average*
Traditional				
Nepal	22	3.1	27	300
India				
Gujarat	45	6.4	—	—
Haryana	51	3.3	51	6
Karnataka	38	3 2	38	17
Central and South India	129	4.6	129	51
Pauri Garhwal	95	5.6	100	21
Tehri Garhwal	50	1 2	—	—
Pune, urban poor *	—	1 1	—	8
Ahmedabad, urban poor	20	2.6	20	165
Delhi slums *	80	1 2	80	12
Improved				
Nepal	27	1 1	26	67
India				
Gujarat	14	4.6	—	—
Haryana	36	2 9	36	5
Karnataka	38	2 5	38	8

* respirable particulate matter

Sources

1 Reid H, Smith K R, Sherchand B 1986 Indoor smoke exposures from traditional and improved cookstoves· comparisons among rural Nepali women Mountain Research and Development 6(4)

2 Smith K R, Aggarwal A L, Dave R M 1983 Air pollution and rural biomass fuels in developing countries a pilot village study in India and implications for research and policy Atmospheric Environment 17(11)

3 Ramakrishna J 1988 Patterns of Domestic Air Pollution in Rural India , Ph D Dissertation, University of Hawaii

4 Menon P 1988 Indoor Spatial Monitoring of Combustion Generated Pollutants (total suspended particulates, carbon monoxide, and BAP) by Indian Cookstoves Ph D Dissertation, University of Hawaii

5 Saksena S, Prasad R , Pal R C, Joshi V Patterns of daily exposure to total suspended particulates and carbon monoxide in the Garhwal Himalaya Atmospheric Environment 26(11) 2125–2134

6 TERI 1995 Biomass fuels, indoor air pollution and health - a multi-disciplinary, mulit-center study (phase 1B) Final report submitted to Biomass Users Network, USA New Delhi Tata Energy Research Institute 58 pp

7 Raivani C V, Shah S H, Desai N M, Venkaiah K, Patel J S, Parikh D J, Kashyap S K 1993 Characterization and problems of indoor pollution due to cooking stove smoke Atmospheric Environment 27A (11) 1643–1655

8 TERI 1995 Health risks and cost-effective interventions for indoor air pollution Final report submitted to The Catholic University of Louvain, Belgium New Delhi Tata Energy Research Institute

9 Smith K R, Apte M G, Yuqing M A, Wongsekiarttirat W, Kulkarni A 1994 Air pollution and the energy ladder in Asian cities Energy 19(5) 587–600

Table 45

List of projects requiring environmental clearance

Number	*Projects*
1	Nuclear power and related projects such as heavy water plants, nuclear fuel complexes, rare earth
2	River valley projects, including hydel power, major irrigation, and their combination including flood control
3	Ports, harbours, and airports (except minor ports and harbours)
4	Petroleum refineries including crude and product pipelines
5	Chemical fertilizers (nitrogenous and phosphatic other than single super phosphate)
6	Pesticides (technical)
7	Petrochemical complexes (both olefinic and aromatic) and petrochemical intermediates such as dimethyl terephthalate, caprolactam, LAB, etc. and production of basic plastics such as low-density polyethylene, high-density polyethylene, polypropylene, polyvinylchloride
8	Bulk drugs and pharmaceuticals
9	Exploration for oil and gas and their production, transportation, and storage
10	Synthetic rubber
11	Asbestos and asbestos products
12	Hydrocyanic acid and its derivatives
13	- Primary metallurgical industries (e.g., production of iron and steel, aluminium, copper, lead, and ferro alloys) - Electric arc furnaces (mini-steel plants)
14	Chlor-alkali industry
15	Integrated paint complexes including manufacture of resins and basic raw materials required in the manufacture of paints
16	Viscose staple fibre and filament yarn
17	Storage batteries integrated with manufacture of oxides of lead and lead–antimony alloy
18	All tourism projects between 200 m and 500 m of high-tide line or at locations with an elevation of more than 100 m with investment of more than 50 million rupees
19	Thermal power plants
20	Mining projects (major minerals) with leases more than 5 ha
21	Highway projects
22	Tarred roads in Himalaya and/or forest areas
23	Distilleries
24	Raw skins and hides
25	Pulp, paper, and newsprint
26	Dyes
27	Cement
28	Foundries (individual)
29	Electroplating

Source

MoEF. 1994 The Environmental Impact Assessment Notification New Delhi Ministry of Environment and Forests

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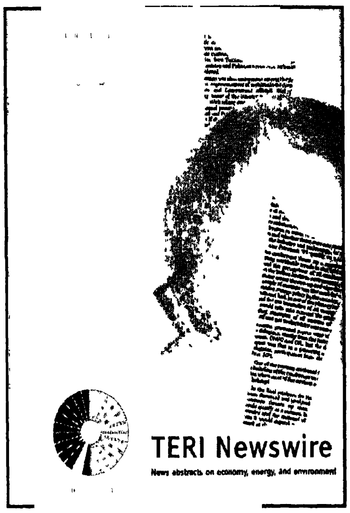

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Global environment issues

The pressure on global natural resources and ecosystems is increasing day by day due to a wide range of human activities. Some of the key environmental problems faced by the world today include the threat to physical and biological resources, depletion of the ozone layer, and rising temperatures due to climate change. This chapter covers issues related to biodiversity, ozone depletion, and climate change.

Biological diversity

Biological diversity or biodiversity is defined as 'the variety and variability among living organisms and the ecological complexes in which they occur' (Gaston 1996). Across the world, biodiversity is facing a barrage of threats in the form of loss and fragmentation of habitats, over-exploitation, spread of exotic species and diseases, air, soil and water pollution, and climate change (Soule 1991). There is evidence indicating that current efforts at conserving biodiversity are inadequate to tackle the problem. This is further complicated by the uncertainty over the extent of diversity, the rate at which it is being depleted, and the identity of the species going extinct. Estimates of the number of species vary widely from 3 to 30–50 million species. Unfortunately, this uncertainty surrounding the number of species also leads to imprecision in predicting the number of species extinction since most current estimates are based on extrapolations of existing species.

Growing concern over the continuous erosion of genetic diversity (Table 1) and disappearance of species at rates unprecedented in history led to global recognition that something has to be done to at least slow down this trend. This was buttressed by the knowledge that preserving biodiversity was necessary for its actual and potential economic value, particularly in the pharmaceutical, biotechnology, and agricultural spheres; its role in regulating environmental processes; and for aesthetic and ethical reasons (Ehrlich and Wilson 1993). The obvious need for initiating conservation programmes formed the backdrop for global institutional measures and regimes targeted at halting this widespread degradation. While there were a number of international treaties devoted to saving endangered species that focused on specific species or habitats, the need was felt for an overarching treaty that would encompass the many different accords relating to conservation and provide an integrated framework for the conservation of biodiversity.

In this context, negotiations for an international policy regime on biodiversity gained momentum in the late 1980s. In 1987, the UNEP (United Nation Environment Programme) established the Ad Hoc Working Group of Experts on Biological Diversity. Subsequently, the Intergovernmental Negotiating Committee for a Convention on Biodiversity was set up in 1991. After months of negotiations, in May 1992, 101 governments adopted the final agreed text of the CBD (Convention on Biological Diversity) in Nairobi. The Convention was signed by 159 governments and the European Union at the Earth Summit in Rio in June 1992 and came into force on 29 December 1993.

The Convention on Biological Diversity

The CBD is a legally-binding framework treaty that has been ratified by over 170 countries. Unlike other conventions, the CBD provides overall goals and policies that can guide decision making at the national level. Therefore, precise obligations, timetables, targets, and lists of habitats and species to be protected are missing from its provisions. The CBD has three main thrust areas: (1) conservation of biodiversity, (2) sustainable use of biological resources, and (3) equitable sharing of benefits arising from its sustainable use. Although the primary focus of the Convention was the conservation of biodiversity, developing countries played a pivotal role in transforming the nature of the discussions in the CBD and expanding its mandate to include issues of ownership and access to natural resources and technologies.

At the Rio summit, it was decided to: (1) develop the biosafety protocol, (2) create the clearing house mechanism for scientific and technological cooperation, and (3) form the SBSTA (Subsidiary Body for Scientific and Technological Advice) to provide substantiating scientific evidence and assistance in the pursuance of the CBD's activities. While the SBSTA and the Clearing House Mechanism have been created, the proposed Biosafety Protocol still languishes since Parties have been unable to agree on some contentious issues relating to trade, treatment of commodities, and domestic–international regulatory regimes. Various work programmes have been initiated on a number of aspects and to date 34 nations have initiated national biodiversity studies, of which nearly half is complete.

Convention on Biological Diversity negotiations: key issues

Right from its inception, the CBD negotiations soon became entangled in a North–South struggle over access to biological and genetic resources and IPRs (intellectual property rights). While most of the biodiversity lies in the South, technologies for its utilization are concentrated in the hands of the northern countries, particularly the US, European countries, and Japan. Prior to the Convention, plant genetic resources were considered to be part of the 'common heritage' of humankind and thus were freely available for biotechnological firms for a variety of purposes, including commercial applications. Ironically, while the initial genetic resources were open to development by whoever had access to them, the outcomes of these plant-breeding experiments using these genetic resources were protected by IPRs and patents. Developing countries pointed out the injustice of allowing industrialized nations free access to their own genetic resources, which were subsequently patented and sold back to them at high prices (Porter 1992).

Rejecting the 'common heritage' concept, developing countries at the CBD instead sought to link access to resources in the South to technology transfer and products developed in the North (Porter 1992). Consequently, the South argued that national sovereignty over biological resources should be recognized. The South was successful in its demands and Article 3 of the Convention guarantees nations the sovereign right to exploit their natural resources pursuant to their own environmental policies. Additionally, biological resources are no longer the common heritage but the common concern of humankind.

While the South was successful in getting the issue of national sovereignty included in the Convention, they were unable to obtain any obligations from the developed world for technological transfers. Instead the developed countries ensured that such transfers take place subject to mutually-agreed terms (Raustiala and David 1996).

Biosafety, which refers to the risks associated with the biotechnological modifications of living organisms, was another controversial issue that led to the polarization of nations along North–South lines. The North feared that signing the Biosafety Protocol would lead to the introduction of draconian laws by the South that would hamper the development of their own biotechnological industry.

Issues of IPRs and technology transfer rather than biodiversity conservation per se dominated the agenda of the Biodiversity Convention at Rio and continue to do so. Conservation obligations of the CBD have been listed below.

- Development of national plans, strategies, or programmes for the conservation and sustainable use of biodiversity (species, genetic resources, and ecosystems) (Article 6)
- Inventory and monitoring of components of biodiversity and of processes affecting it adversely (Article 7)
- Restoration of degraded ecosystems and recovery of endangered species (Article 8)
- Preservation of indigenous and local systems of biological resource management and equitable sharing of benefits with such communities (Article 8).

Relevance for India

India is rich in biological diversity and home to two of the world's 18 biological hotspot regions of high biodiversity and endemism (Tables 2 and 3). Some of the Indian species of biodiversity have driven the debate over access to biodiversity and equitable benefit-sharing mechanisms, including technology transfer. The Indian neem (*Azadirachta indica*) tree, for example, is a source of 50 US patents for products ranging from contraceptives to pesticides, leading to arguments that these are not new innovations but are derived from ancient Indian medicinal systems (Raustiala and David 1996). The CBD, therefore, has important implications for India: for conservation, sustainable use of biodiversity as well as issues pertaining to access to genetic resources and technology transfer.

The CBD and its concern over the protection of biodiversity, its sustainable use, and access to Indian biodiversity have given rise to a draft Biological Diversity Act for India. This draft is being reviewed, discussed, and amended, before it will be submitted to the Parliament for its approval and passage. Among the other actions that India needs to take regarding the CBD are (1) finalization of the National Biodiversity Action Plan, (2) passing of the draft Act mentioned above in consultation with various stakeholders, (3) analysis of the impact of trade agreements on Indian biodiversity, and (4) rationalization of the various acts dealing with biodiversity and IPR regimes (Box 1). One million dollars has been granted to India by the GEF (Global Environment Facility) to prepare a national strategy and action plan (Kothari 1998).

Box 1 Central Indian Acts of relevance to biodiversity conservation

- Fisheries Act, 1897
- Destructive Insects and Pest Act, 1914
- The Indian Forest Act, 1927
- Indian Coffee Act, 1942
- Agricultural Produce (Grading and Marketing) Act, 1937
- Import and Export (Control) Act, 1947
- Rubber (Production and Marketing) Act 1947
- Tea Act, 1953
- Prevention of Cruelty to Animals Act, 1960
- Customs Act, 1962
- Cardamom Act, 1965
- Seeds Act, 1966
- Wildlife (Protection) Act, 1972, and Wildlife (Protection) Amendment Act, 1991
- Marine Products Export Development Authority, 1972
- Water (Prevention and Control of Pollution) Act, 1974
- Tobacco Board Act, 1975
- Territorial Water, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Acts, 1976
- Water (Prevention and Control of Pollution) Cess Act, 1977
- Coconut Development Board Act, 1979
- Maritime Zones of India (Regulation and Fishing by Foreign Vessels) Act, 1980
- Forest (Conservation) Act, 1980
- Air (Prevention and Control of Pollution) Act, 1981
- National Oilseeds and Vegetable Oils Development Board, 1983
- Agricultural and Processed Food Products Export Development Authority Act, 1985/1986
- Environment (Protection) Act, 1986
- Spices Board Act, 1986
- National Dairy Development Board Act, 1987
- New Seed Development Policy, 1988
- Foreign Trade (Development and Regulation) Act, 1992

Source MoEF (1997)

Review of the Eighth Five-Year Plan (1992–97)

Significant measures related to biodiversity were taken in the Eighth Five-Year Plan (GoI 1997).

- A scheme on biodiversity conservation was initiated during 1991/92 to facilitate coordinated action among various agencies and the development of appropriate policy instruments.
- Conservation and survey activities were carried out by the Botanical Survey of India and the Zoological Survey of India.

Objectives of the Ninth Five-Year Plan (1997–2002)

The activities regarding biodiversity proposed in the Ninth Five-Year Plan are as follows (GoI 1997).

- It is proposed to focus on modernization of taxonomic surveys, creation of a national database on biodiversity, and provision of facilities for characterization of bioresources at the molecular level.
- Administrative infrastructure to promulgate, administer, and implement regulations governing the use of bioresources is to be created and strengthened.
- The need for drafting a comprehensive legislation on biological diversity is recognized.
- A biodiversity cell is to be set up in the Ministry of Environment and Forests.
- The Biosphere Reserve Management Programme is intended to conserve representative ecosystems.
- Ongoing schemes are in place for the conservation and management of mangroves and wetlands.

- Four coral reefs (Gulf of Kachch, Gulf of Mannar, Andaman and Nicobar Islands, and Lakshadweep Islands) have been identified for intensive conservation and management.

Stratospheric ozone depletion

Ozone forms a layer in the stratosphere 10–50 km above the earth's surface, protecting it from harmful ultraviolet radiation. Over the past 10–15 years, the ozone layer has lost up to 8% in winter in mid and high latitudes and up to 60% in Antarctica during the southern spring. Over Antarctica, the land area under the ozone-depleted atmosphere has steadily increased to 20–25 million km^2 (UNEP 1992). The resulting increase in incoming ultraviolet radiation could have grave consequences for human and ecological health. This radiation could change genetic structure, alter immune systems, inhibit plant growth, and increase the incidence of cataracts and skin cancer.

The destruction of the ozone layer is caused by chlorine and bromine compounds, which primarily come from CFCs (chlorofluorocarbons) and halons. These long-lived human-made chemicals are used in a wide variety of products, ranging from refrigerators to cleaning solvents. Table 4 illustrates the trends in atmospheric concentrations of some of these compounds. Before industrialization, natural atmospheric chlorine levels were only 0.6 PPBV (parts per billion by volume). At present, however, the concentration of chlorine compounds has risen to 3.0–3.5 PPBV (UNEP 1992).

The first attempt to address the problem of stratospheric ozone depletion was made in 1981 with the onset of inter-governmental negotiations for an international agreement to phase out ODS (ozone depleting substances). In 1985 – the same year that the ozone hole over Antarctica was discovered – 21 countries and the European Community adopted the Vienna Convention for the protection of the ozone layer. The Vienna Convention created a general obligation for countries to take appropriate measures to protect the ozone layer. Although it did not define these measures, it succeeded in establishing a mechanism for international cooperation, and laid down the framework for a future legally binding protocol to control ODS (Benedick 1998). Subsequently, the Montreal Protocol on Substances that Deplete the Ozone Layer was finalized and approved in 1987.

The Montreal Protocol

The Montreal Protocol entered into force in 1989, and was ratified by 36 countries that together accounted for 80% of the global CFC consumption. It aimed at reducing the production and use of five most widely used CFCs (CFC-11, 12, 113, 114, and 115) and three major halons (1211, 1301, and 2402). Special provisions were made for developing countries whose per capita consumption of the ODS (ozone depleting substances) was less than 0.3 kg. The Protocol has been significantly updated four times to accelerate the phase-out schedules and include new controlled substances. At present, it controls 95 chemicals and has been ratified by 168 Parties. The timetable for the phase-out of ODS under the Protocol and its subsequent amendments is given in Table 5.

The Montreal Protocol has resulted in a sharp decline in the manufacture and use of CFCs. In 1986, the global consumption of CFCs was about 1.1 million tonnes, by 1997 this declined to about 146 000 tonnes (UNEP 1999). Figure 1 represents the decline in the annual production of CFCs over the period 1986–95.

It is estimated that in the absence of the Montreal Protocol, the global consumption of CFCs would increase unchecked to 3 million tonnes by 2010 and 8 million tonnes by 2060. This would

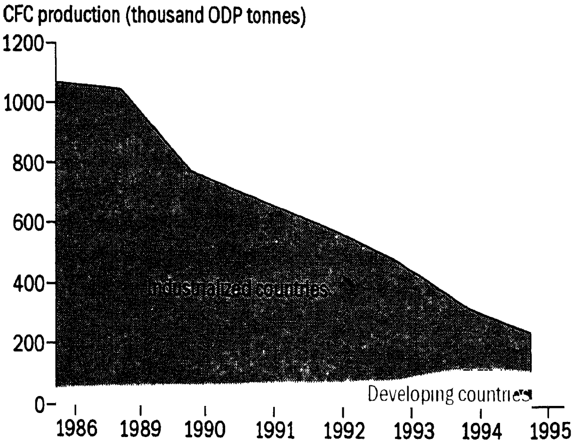


Figure 1 Annual production of CFCs (chlorofluorocarbons): 1986-95

Note ODP (ozone depleting potential) tonnes is a measure by which ozone depleting substances are weighted according to their ability to destroy ozone

Source Oberthur (1997)

mean that by 2035, the ozone layer would be depleted by 50% (UNEP 1999). Projections of ozone losses with and without the Protocol have been illustrated in Figure 2.

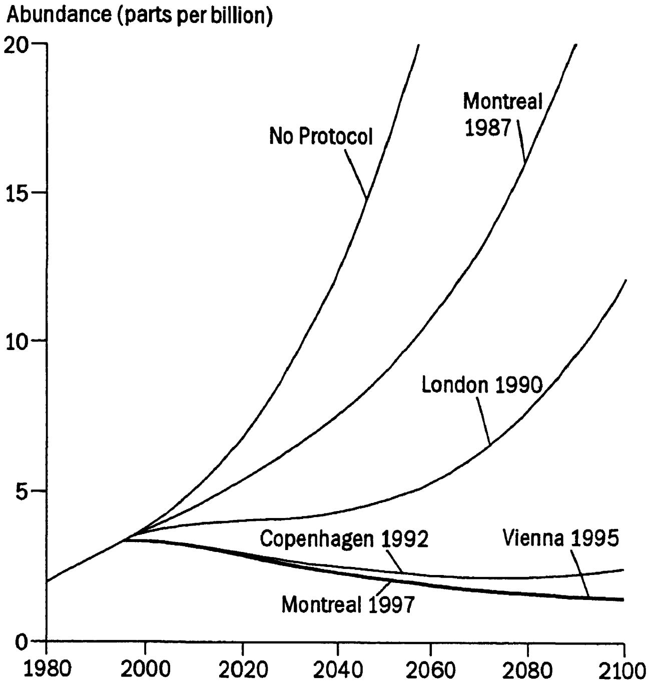


Figure 2 Projection of ozone losses without the Montreal Protocol
Source UNEP (1999)

The success of the Montreal Protocol, however, is threatened by the growth of a black market in CFCs and the difficulties in compliance faced by Russia and some East European countries. In addition to this, the use of ODS is increasing in some developing countries. In particular, as illustrated in Figure 3, there continues to be an upward trend in the production of halons, which destroy 3–10 times more ozone than CFCs (WRI 1998).

The Indian scenario

In 1991, India's per capita consumption of ODS was less than 10 g, far below the level (300 g) permitted by the Montreal Protocol for developing countries. India's consumption of ODS in 1991 was about 10 370 tonnes. Of this, about 85% was produced domestically and 15% was imported. In ODP (ozone-depleting potential) terms, the total consumption was 13 111 tonnes. The use of these substances is in the sectors that produce and consume essential goods and services. The maximum consumption was of carbon tetrachloride, followed by CFC-12 (GoI 1993). The sectorwise and substancewise break-ups of ODS consumption are shown in Figure 4.

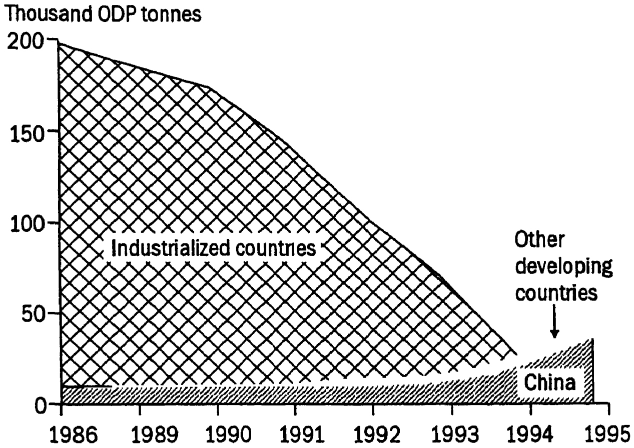
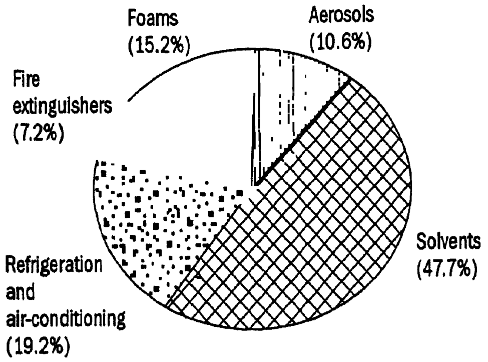


Figure 3 Annual production of halons: 1986-95
Source Oberthur (1997)

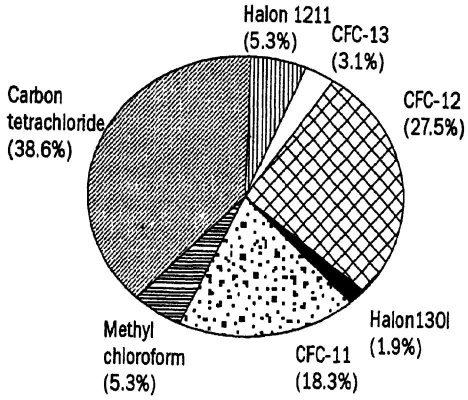
India became a Party to the Vienna Convention in June 1991 and to the Montreal Protocol in September 1992. The 'India Country Programme for the Phase-out of ODS under the Montreal Protocol' was approved in November 1993. The projections for unconstrained ODS consumption were made in 1993, based on the development plans of each sector using these substances. These have been estimated to be around 184 200 tonnes in 2010. In terms of ODP, the unconstrained demand in 2010 would be 199 308 tonnes (GoI 1993) (Figure 5).

The consumption of CFCs has largely remained constant during the last few years, while consumption of halons, which could have risen significantly, has declined considerably. The ODS phase-out to be achieved from current approved ODS projects in India is over 4500 ODP tonnes (MoEF 1998). Table 6 gives the projected phase-out of ODS production by 2010.

In order to ensure that the objectives of the Country Programme are achieved with minimum economic dislocation and obsolescence costs, the MoEF established the Ozone Cell. The Ozone Cell is responsible for inter-ministerial interaction and for the integration of policies and programmes. The



By sector



By substance

Figure 4 Break-up of ODS (ozone depleting substances) consumption by sector and substance
Source MoEF (1998)

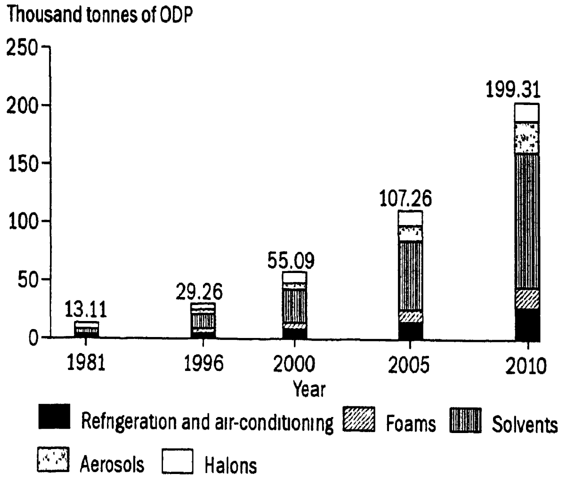


Figure 5 Estimated unconstrained ODP (ozone-depleting potential) demand by sector up to 2010
Source GoI (1993)

MoEF has also set up an inter-ministerial Steering Committee on the Montreal Protocol, which is responsible for the implementation of the Protocol's provisions, review of policy and implementation options, project approval, and project monitoring. The Committee took a series of important decisions, which encourage the use of non-ODS, some of which are listed below (MoEF 1998).

- The goods required to implement ODS phase-out projects funded by the Multilateral Fund are fully exempt from payment of duties. This benefit has been extended to all enterprises that were eligible to receive Multilateral Fund assistance, and recently for new investments with non-ODS technologies.
- Strategy reports for all the individual technology sectors using ODS are under preparation. Among these, the reports for the refrigeration and air-conditioning, solvents, and aerosols sectors have already been prepared.
- In order to discourage the use of ODS, financial institutions and commercial banks are encouraged to stop finance or re-finance for investments involving ODS technologies.
- Rules for the formal regulation of ODS phase-out have been drafted by the MoEF, following consultations with industries and related government departments. These policy measures were intended to support Multilateral Fund assistance. These have been provided for wider public comment, and would be published after finalization and addressing the comments.
- While a comprehensive regulation on ODS is being prepared, some of the regulatory measures taken so far include a ban on trade in ODS with non-Parties, compulsory licensing for import and export of ODS listed in Annex A and B of the Protocol, a ban on their export to non-Article 5 Parties, and the introduction of labelling newly-produced CFCs for export to Article 5 countries.

India has made significant progress in reducing the use of ODS as of now. However, considerable work remains to be done in phasing out ODS use in small and medium enterprises and process agents, and in phasing out ODS production. The needs of the servicing sector are yet to be addressed. Many of these issues require policy decisions by the Multilateral Fund established under the Montreal Protocol. The Protocol should also address the needs of end-users. It should be ensured that funding decisions do not lead to the transfer of the burden of change-over to developing countries. In addition to these, some basic impediments in the transfer of environment-friendly technologies need to be removed (MoEF 1998).

Climate change

The Second Assessment Report of the IPCC (Intergovernmental Panel on Climate Change)[1] points out that 'the balance of evidence suggests a discernible human influence on global climate'.

The natural greenhouse effect plays a crucial role in regulating the heat balance of the earth. It allows the incoming short-wave solar radiation to pass through the atmosphere relatively unimpeded. However, the long-wave terrestrial radiation emitted by the earth's surface is partially absorbed and then re-emitted by a number of trace gases in the atmosphere, collectively known as GHGs (greenhouse gases). The main GHGs include water vapour, carbon dioxide, methane, CFCs, nitrous oxide, and ozone in the troposphere and stratosphere.[2] This phenomenon keeps the global atmosphere warmer by about 33 °C and is vitally important for life on earth.

Since the Industrial Revolution, anthropogenic activities, especially fossil-fuel combustion and deforestation, are increasing the concentrations of atmospheric GHGs beyond their natural state, resulting in the enhanced greenhouse effect. This causes an increase in global temperatures, which is known as global warming. This warming can be amplified through positive feedbacks such as increase in water vapour, or reduced through negative feedbacks such as increase in stratospheric aerosols. The sum of all these potential changes is referred to as climate change.

Each GHG has a different GWP (global warming potential), which depends on its ability to trap the outgoing radiation and on its residence time in the atmosphere (some characteristics of the major GHGs are provided in Table 7). The GWP is estimated using carbon dioxide as an index, and future concentrations of all anthropogenic GHGs are also often presented and aggregated in terms of carbon dioxide levels. This is because, though carbon dioxide is the least potent GHG, with large emission levels it is the largest contributor to the greenhouse effect.[3]

The enhanced greenhouse effect is often expressed in terms of 'radiative forcing'. Radiative forcing is defined as the change in net downward radiation (combined solar and infrared) at the tropopause. The radiative forcing due to human-made GHGs is currently estimated at about 2.45 W/m^2. A doubling of carbon dioxide concentration from its pre-Industrial Revolution level, i.e., from 280 to 560 PPMV (parts per million by volume) (denoted by 2 × carbon dioxide), is expected to result in a radiative forcing of more than 4 W/m^2.

Sources and sinks of greenhouse gases

The major anthropogenic sources of GHG emissions can be categorized as follows.

- The energy sector is currently the dominant source of global carbon dioxide emissions (Tables 8 and 9). Fossil-fuel combustion results in large emissions of carbon dioxide, while a small amount of methane emissions takes place from coal mining and the venting of natural gas.
- Industrial processes, in particular cement production, are among the main contributors of GHG emissions. Production and use of CFCs and other halocarbons in various industrial processes also contribute to enhanced radiative forcing.
- Changes in land-use patterns, particularly deforestation, decomposition of forest litter and the inefficient burning of biomass fuels are also responsible for increases in atmospheric carbon dioxide and methane.
- Methane is released from rice cultivation and livestock systems, while nitrous oxide is released during the use of nitrogenous fertilizers.

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[1] The IPCC was jointly established by the World Meteorological Organization and the United Nations Environment Programme in 1988 to (1) assess available scientific information on climate change, (2) assess the environmental and socio-economic impacts of climate change, and (3) formulate response strategies. The Panel has established three working groups to undertake these tasks. The IPCC publishes its findings after a rigorous survey of literature, and contributions from experts around the globe. The most recent report of the IPCC has been the Second Assessment Report.

[2] Four principal gases (nitrogen, oxygen, argon, and carbon dioxide) constitute 99.97% of the atmosphere (excluding water vapour); other gases (neon, methane, krypton, helium xenon, hydrogen, carbon monoxide, nitrous oxide, nitrogen dioxide, sulphur dioxide, radon, and ozone) are present only in traces.

[3] Carbon dioxide, methane, and nitrous oxide together have contributed about 80% of the additional climate forcing due to GHGs since the Industrial Revolution, with carbon dioxide accounting for 60% of the total.

- Other sources of GHGs include methane from landfills.

The relative contribution of different sectors to the change in radiative forcing over the period 1980–90 is shown in Figure 6.

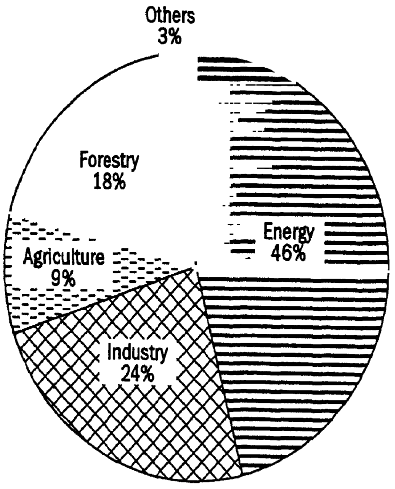

Figure 6 Contribution of different sectors to change in radiative forcing (1980-90)
Source IPCC Secretariat (1990)

There are also a number of natural sinks for GHGs. The ocean is an important reservoir of carbon dioxide. Vegetation and soils also have the capacity to sequester carbon dioxide. The major sink for atmospheric methane, on the other hand, is its reaction with OH (hydroxyl) in the troposphere (the OH concentration being controlled by a complex set of reactions involving methane, carbon monoxide, non-methane hydrocarbons, oxides of nitrogen, and tropospheric ozone). Soils may also provide a removal mechanism for methane. Tables 10 and 11 provide details on sources and sinks of carbon dioxide and methane.

Temperature rise and sea-level changes

The mean global surface temperature has increased by about 0.3 °C to 0.6 °C since the late 19th century, and by about 0.2 °C to 0.3 °C over the past 40 years. Although there is a distinct trend in the global average temperature, the increase is by no means uniform (Figure 7). It has been observed that the warming occurred largely during two periods, between 1910 and 1940 and since the mid-1970s to the present time. The recent years have been the warmest since 1986. Also, the warming has not been globally uniform, with the northern hemisphere experiencing more warming than the southern hemisphere.

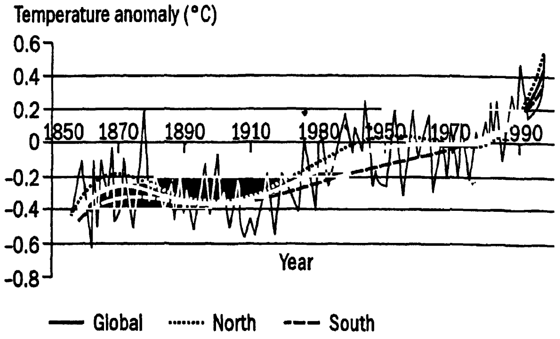

Figure 7 Temperature anomalies
Source IPCC Secretariat (1996)

A rise in global temperature is expected to increase the sea level by expanding ocean water, melting mountain glaciers, and causing the ice sheets of Greenland and Antarctica to melt or slide into the oceans. Global sea level has risen by 10–25 cm over the past 100 years and much of the rise may be related to the increase in global mean temperature. Changes in surface temperature and sea level could further result in changes in precipitation quantity and pattern, changes in vegetation cover and soil moisture, and increased intensity of storms and other extreme events.

The IPCC has developed a range of scenarios (IS92 a–f) of future GHG and aerosol precursor emissions based on assumptions concerning population and economic growth, land-use, technological changes, energy availability, and fuel mix during 1990 to 2100. In all cases, the atmospheric concentrations of GHGs and total radiative forcing continue to increase throughout the simulation period of 1990 to 2100. The predicted increase in temperature and the rise in sea level for various scenarios are shown in Figures 8 and 9. The current estimates of temperature rise associated with the benchmark scenario vary from 1.0 °C to 3.5 °C, with the best estimate of 2 °C by 2100 (IPCC Secretariat 1996, p.6). These expected changes in global temperatures are greater than any seen in the last 10 000 years. Further, the regional temperature changes could be substantially different from the global average.

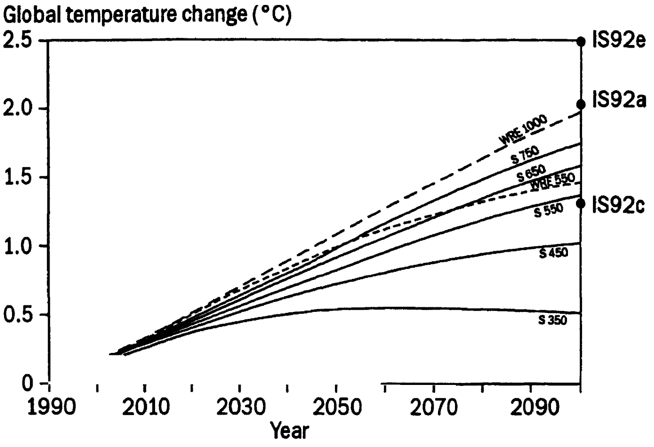

Figure 8 Projected global mean temperature change relative to 1990 levels for various greenhouse gas stabilization scenarios

Source IPCC Secretariat (1997)

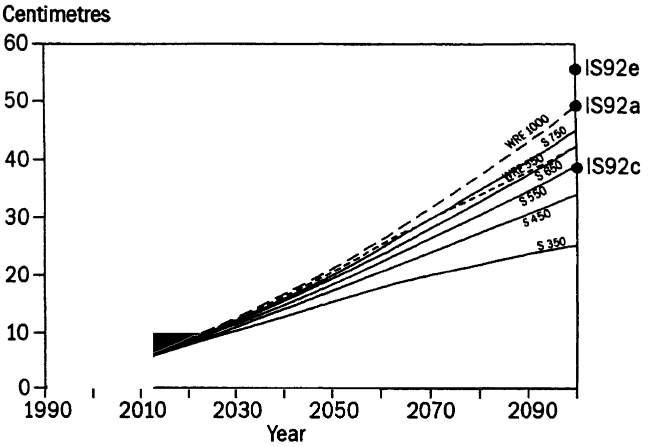

Figure 9 Projected global sea-level change relative to 1990 levels for various greenhouse gas stabilization scenarios

Source IPCC Secretariat (1997)

For sea-level rise, the IPCC's IS92a scenario, assuming the 'best estimate' values of climate sensitivity and ice melts sensitivity to warming models, projects an increase of about 50 cm from the present level by 2100. The projected rise is 2–5 times faster than the rise experienced in the past 100 years.

For India, the results from the equilibrium General Circulation Model experiments show that the temperature rise in northern India would be higher than that in southern India. The average change across India is predicted to be in the range of 2.33 °C to 4.78 °C for the benchmark 2 × carbon dioxide scenario (Lonergan 1998).

Impacts of climate change

Climate change is likely to have a number of market and non-market impacts. The market impacts include those on agriculture, coastal infrastructure, water supply, forestry, and energy demand. The non-market impacts refer to the situation where there are no markets to directly evaluate the economic losses or benefits due to climate change. These include impacts on biodiversity, human health, and risk to life due to extreme weather events.

Estimating the potential impacts of climate change is difficult due to the vast extent of uncertainty involved. Though there is a fairly broad consensus among climatologists about the expected changes in global mean temperature, the confidence level is lower while predicting regional and seasonal variations and also the changes in temperature-dependent variables such as precipitation, evaporation, storm frequency, and sea level. Even if the degree of change in climate variables is known precisely, the effect it would have on human health, the ecosystem, and agricultural yields is far from being clearly understood. In this light, most studies on impact assessment have confined themselves to the 2 × carbon dioxide scenario.

Table 12 provides estimates of the overall annual damage costs corresponding to 2 × carbon dioxide climate change for different regions of the world based on studies by Fankhauser (1995) and Tol (1995).[4] Overall, it appears that more severe impacts can be expected in Asia and Africa as compared to higher latitude countries. The developing countries are more vulnerable to effects of climate change as their economies are more dependent on climate-sensitive sectors, like agriculture and forestry, and they have less technical, institutional, and financial capacity to adapt to the effects. Table 13 shows the overall impacts of a 2 × carbon dioxide climate change on a regional basis as percentage of the GDP.

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[4] Both these studies have depended on more or less the same sources; hence the similarity in estimates does not necessarily imply that they are robust.

India-specific impacts

As the Indian economy depends to a great extent on agriculture – a highly climate-sensitive sector – the assessment of climate change impacts on agriculture has acquired special significance. Rao and Sinha (1994) in their crop-simulation study have estimated that under a 2 × carbon dioxide climate change scenario, the wheat yields could decrease by 28%–68% without considering the carbon dioxide fertilization effects. In a recent study, Kumar and Parikh (1998) have examined the adaptation options while estimating the agricultural impacts. The study showed that even with adaptation by farmers of their cropping patterns and inputs, in response to climate change, the losses would remain significant. The loss in farm-level net revenue is estimated to range between 9% and 25% for a temperature rise of 2 °C–3.5 °C.

A rise in sea level may also have significant implications on the coastal population and agricultural performance of India. The costs of 1-m sea-level rise for India have been estimated in JNU (1993). According to the estimates, in the absence of protection, approximately seven million people would be displaced, and 5764 km^2 of land and 4200 km of roads would be lost. The dominant cost as indicated in Table 14 is land loss, which accounts for 83% of all damages. The extent of vulnerability, however, depends not just on the physical exposure to sea-level rise and population affected, but also on the extent of economic activity of the areas. In a study undertaken by TERI, a relative ranking by vulnerability to sea-level rise of the coastal districts of India has been provided using a weighted index (TERI 1996).[5] Mumbai and Ratnagiri districts in Maharashtra were found to be the most and least vulnerable, respectively, to a 1-m sea-level rise. The study further estimated the potential economic impacts and the value of coastal protection against this sea-level rise for three representative districts. The results of this study are given in Table 15.

The intensity and frequency of cyclone storms in the Arabian Sea and the Bay of Bengal could also be affected under changed climatic conditions. In the case of the North Indian Ocean, it is estimated that the average number of tropical disturbance days could increase from 17 to 29 per year under 2 × carbon dioxide conditions (Haarsma, Mitchell, and Senior 1993).

North-South contributions to climate change

It is evident that humankind's continuing dependence on fossil fuels has led to the increase in GHG emissions. Figure 10 shows carbon emissions from fossil fuel burning over the period 1950 to 1997. The geographical distribution of GHG emissions is not uniform (Table 16). Table 17 lists the top 10 GHG-emitting countries. Developed countries have made a far greater contribution to the atmospheric stock of carbon dioxide than annual emissions profiles suggest. Figure 11 shows that developed countries have contributed roughly 80% of the carbon dioxide, which has accumulated in the atmosphere over the period 1850–1995, from industrial sources (Austin, Goldemberg, and Parker 1998).

Although India figures among the top 10 contributors to GHG emissions, its relative share is low in terms of per capita emissions. The current gross emissions per capita in India are only one-sixth of the world average (ADB 1994).

The national GHG inventory for India was prepared by the NPL (National Physical Laboratory) as a part of the ALGAS (Asia Least-Cost Green-

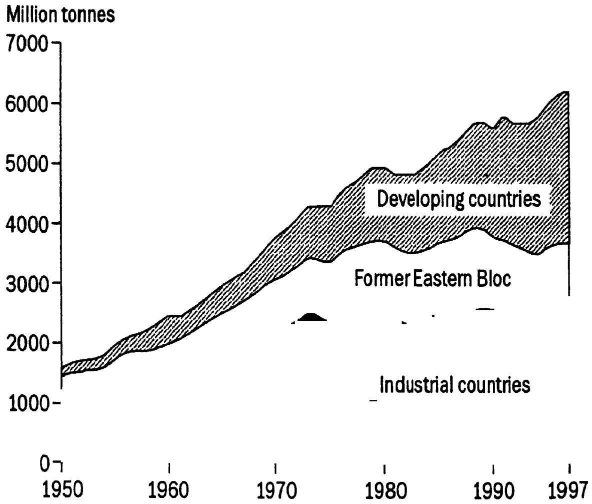

Figure 10 Carbon emissions from fossil fuel burning: 1950-97
Source Dunn (1998)

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[5] The weighted average was constructed using three parameters at the district level: share of land affected in the total area, share of population affected in the total population, and the Centre for Monitoring Indian Economy index of relative development.

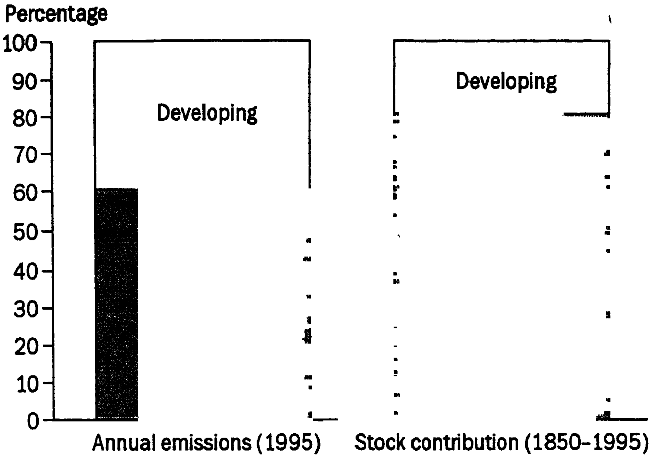

Figure 11 Relative contribution from industrial sources
Source Austin, Goldemberg, and Parker (1998)

house Gas Abatement Strategy) Project[6] using the methodology prescribed by the IPCC. The sectorwise inventory prepared is presented in Table 18. The total carbon dioxide-equivalent emissions from India are estimated to be 1 001 352 Gg, which is about three per cent of the total global carbon-dioxide-equivalent emissions. Based on this, the per capita carbon dioxide-equivalent emissions for 1990 are estimated to be 1.194 tonnes or 325 kg of carbon. In comparison, the per capita emissions for Japan and the US are 2400 and 5400 kg of carbon, respectively in 1990 (ADB 1998).

Framework Convention on Climate Change

Climate change was recognized as a major global concern at the First World Climate Conference held in 1979. The IPCC was set up in 1988 to assess the seriousness of the problem and recommend policy instruments. In 1991, negotiations began on a global treaty on climate change, which came to be known as the FCCC (Framework Convention on Climate Change). This was adopted at UNCED (United Nations Conference on Environment and Development) at Rio de Janeiro in June 1992, and came into force on 21 May 1994.

The ultimate objective of the FCCC is to 'achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner' (FCCC Secretariat 1992).

In order to achieve its objective, the Convention provides commitments to various Parties to reduce their emissions based on the principles of 'equity' and 'common but differentiated responsibilities'. It called upon the developed (or Annex I) countries to stabilize their GHG emissions at 1990 levels by 2000, and move towards quantified emission limits and reduction commitments.

The Convention, however, did not provide abatement targets beyond this period, and it was recognized at COP-1 (First Session of the Conference of Parties to the Convention), that these targets were inadequate for achieving the longer-term objective. By 1996, it was clear that neither the US nor the European Union would reach emission levels below 1990 levels by the year 2000. Thus, efforts were initiated to draft an agreement in order to strengthen these commitments. In December 1998, the Parties to the FCCC adopted a historic Protocol at Kyoto, Japan.

The main features of the Kyoto Protocol are listed below (TERI 1998).

- It covers six major GHGs – carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.
- Annex I Parties would reduce their overall emissions to 5.2% below 1990 levels by the first commitment period (2008–12) – with differentiated targets for various parties (Table 19).
- Annex I Parties can use net changes in GHG emissions resulting from human-induced land-use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, to meet their commitments.
- Annex I Parties that have agreed to jointly fulfil their commitments are allowed to do so by set-

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[6] The overall objective of the ALGAS project, executed by the Asian Development Bank and funded by the United Nations Development Programme / GEF, was to assist participating countries from the Asian region to reduce the rate of growth in their emissions of GHGs. Under the India Country Study component, the NPL was entrusted with the task of developing and refining GHG inventory for India, and TERI was responsible for the identification of the mitigation options and for the development of the least-cost abatement strategy.

ting out their respective emission levels in agreement. This is known as the bubble concept.

- Annex I Parties can carry forward the excess of the assigned amount over emissions from one commitment period to another.
- Three instruments (now known as the Kyoto mechanisms) were introduced to enable Annex I countries to achieve their targets in a flexible and cooperative manner. These were emissions trading, joint implementation, and the CDM (clean development mechanism).

Emissions trading allows countries or companies to achieve cheaper emissions reductions by purchasing emission permits from countries that have excess permits. Joint implementation allows Annex I countries to get credits towards their targets through project-based emission reduction in other such countries. The CDM differs from emissions trading and joint implementation as it involves the participation of developing countries. The CDM enables developed countries to use certified emissions reductions from project activities in developing countries towards attaining compliance with their GHG reduction targets. At the same time, it is intended to assist developing countries in achieving sustainable development and in contributing to the ultimate objective of the FCCC.

While these mechanisms provide flexibility in meeting targets, they have the potential to considerably weaken those targets. An important issue is, therefore, the definition of *caps* or limits on the credits used by Annex I Parties towards meeting their abatement commitments. This is needed to ensure the *supplementarity* of these flexibility options to domestic action in developed countries. From the perspective of developing countries, significant issues include

- *financial additionality* – the funds made available under the CDM should be over and above the Official Development Assistance and GEF funds;
- *project additionality* – the projects chosen under the CDM would not have been implemented in the normal course of events, due to financial , technological, and/or institutional barriers; and
- *environmental additionality* – emissions reductions should be additional to any that would occur in the absence of the certified project activities.

The Kyoto Protocol has been ratified by only 14 countries so far. It will enter into force 90 days after it has been ratified by 55 Parties to the Convention, which account for at least 55% of the total carbon dioxide emission of the industrialized countries. However, the United States, which itself account for 35% of Annex 1emissions in 1990 has not yet ratified the Kyoto Protocol. The COP-4 (Fourth Session of the Conference of Parties to the Convention) was held at Buenos Aires in 1998. At this meeting, the Parties adopted the 'Buenos Aires Work Plan' for strengthening the implementation of the FCCC and preparing for the adoption of the Kyoto Protocol.

Climate change negotiations: key issues

Throughout the long series of negotiations, beginning with the drafting of the FCCC, there have been significant differences in the positions and perceptions of various countries. In the present state of the debate, the issues and provisions that are of utmost importance for developing countries are as follows (TERI 1998).

- The developed countries' call for voluntary commitments or 'meaningful participation' by the developing countries
- Design of the flexibility mechanisms, in particular the CDM
- Financing options made available to the developing countries for climate-related activities
- Development and transfer of efficient and climate-friendly technologies
- Measures for adapting to the adverse impacts of climate change, especially keeping in mind the needs of the most vulnerable countries
- Non-compliance with the abatement targets and other commitments.

While the first two issues have received enormous attention at negotiations and policy forums, the others have been less discussed.

Apart from these shorter-term issues, the importance of some long-term principles that define actions in the future needs to be recognized. In the long term, stabilization of GHG emissions to a pre-determined level would require all countries to move towards what has been termed a 'convergence corridor' (INFRAS AG / TERI 1997).

At Kyoto, a few developed countries, particularly the US, brought up the issue of voluntary commitments by developing countries. They argued that some of the large developing countries, with rapid economic growth and changing lifestyles, are increasingly contributing significant amounts to global GHG emissions. Since the developing countries will be the major contributors to GHG emissions in the future, they should participate actively in efforts to deal with the greenhouse problem. Further, it was argued that developing countries are becoming economically competitive in activities requiring GHG abatement.

However, it has been clearly specified in the Berlin Mandate adopted at COP-1 that the non-Annex I countries would not be required to take any commitments to mitigate the GHG emissions. Despite this, some developed countries are justifying their inaction due to the lack of 'meaningful participation' by developing countries.

The contention of developing countries, however, is that developed countries are responsible for the creation of the greenhouse problem. Their arguments are as follows.

- Developed countries are the major contributors of GHGs and should first give evidence of significant efforts made by them to reduce emissions. It is argued that significant proportions of developing country emissions are necessary for them to follow their development paths. These are 'survival' emissions, as opposed to the 'luxury' emissions of the developed countries.
- The contribution of developing countries is relatively low in terms of per capita emissions or emissions per GDP (at PPP [purchasing power parity]) (Table 20). Moreover, annual emissions understate the stock contribution of developed countries (Figure 11). It would be several decades before developing countries will have contributed as much as developed countries to the build up of carbon dioxide in the atmosphere (Austin, Goldemberg, and Parker 1998).
- Even in the absence of commitments, several developing countries are doing a substantial amount in terms of adopting a less carbon-intensive development path. Their efforts include the promotion of renewable energy resources and the adoption of energy-efficient methods. Many of these actions also include experimenting with technologies that have not yet attained commercial maturity in any market.

Climate change related-policies in India

The Government of India has been very active in the climate change negotiations since the inception of the Convention. The MoEF has constituted a 'Working Group on the FCCC' to deliberate upon measures and positions that should be taken regarding the various issues emerging out of the climate change negotiations. A separate group on the Kyoto mechanisms has also been constituted. Other than these, the Task Group on the 'Pilot Phase of AIJ (activities implemented jointly)' is operational as a mechanism to consider and recommend bilateral and multilateral projects aimed at

- reduction of GHGs,
- elucidation of the methodology for monitoring and tracking of GHGs, and
- addressing the question of sharing benefits.

The MoEF has also been supporting a number of programmes and projects at the regional and the national level, which would have a mitigating impact on GHG emissions. These include the ALGAS project described above. Table 21 lists potential mitigation options that have been identified for various sectors in India, along with their costs.

Review of the Eighth Five-Year Plan (1992–97)

Global environmental problems do not occupy priority positions in the government's policy. However, various measures have been undertaken which have direct relevance for these issues, for instance the promotion of renewable energy programme and afforestion activities. A few such measures undertaken specifically under the Eighth Five-Year Plan include the following (GoI 1997).

- Various afforestation schemes were undertaken during the Eighth Plan period. However, on an aggregate basis, there was a reduction in the forest cover to the extent of 5482 km^2 between the two assessments of 1995 and 1997.
- An ongoing scheme is in place for the promotion of R&D in various aspects of environmental conservation. This includes research projects in climate change.
- Demand-side measures for energy conservation resulted in significant reduction in specific electricity consumption in major energy-intensive industries, such as cement, steel, and pulp and paper.
- The encouragement of new and renewable sources of energy has direct implications for the problem of climate change. The Eighth Plan targets were achieved in the case of socially oriented programmes like biogas, improved chulhas, and low-grade solar thermal devices. However, with the exception of wind power, the programmes for renewable power production fell short of their targets.

Objectives of the Ninth Five-Year Plan (1997–2002)

The Ninth Five-Year Plan has also acknowledged the increasing importance of global environmental issues. One of the stated objectives of this Plan is 'to ensure environmental sustainability of the development process through social mobilization and participation of people at all levels'. However, the strategy for environmental protection in the Ninth Plan relies less on direct action and more on the programmes and policies of various sectors such as energy, transport, and education (GoI 1997). These include the following.

- The annual reports of the Departments of Power and Coal and the Ministry of Petroleum and Natural Gas are required to give a balance sheet of carbon dioxide generated and sinks created by their activities.
- Various demand- and supply-side measures for energy conservation are to be undertaken.
- Environmentally-benign energy systems are to be encouraged with liquefied natural gas being promoted as an environment-friendly source of energy.
- There is an emphasis on the commercialization of new and renewable sources of energy and the phasing out of subsidies.
- R&D in new technologies is to be promoted, e.g., replacement of hydrocarbons in surface transport by alternative fuels, such as compressed natural gas and propane.
- Measures to reduce GHG emissions are to be encouraged, e.g., use of washed coal and various afforestation programmes similar to those undertaken in the Eighth Plan.

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Washington, DC: World Resources Institute.

Table 1

Genetic erosion in crop diversity

Crop name	*Country*	*Number of varieties*
Rice varieties	Sri Lanka	From 2000 varieties in 1959 to 5 major varieties in widespread cultivation today
Rice	India	From 30000 varieties to 75% of production from less than 10 varieties
Rice	Indonesia	74% of varieties descended from one maternal plant
Potato	US	75% of crop in 4 varieties
Cotton	US	50% of crop in 3 varieties
Soyabean	US	50% of crop in 6 varieties
Wheat	US	50% of crop in 9 varieties

Source

UNEP. 1993. Global Biodiversity. Nairobi. United Nations Environment Programme.

Table 2

Comparative assessment of number of species in India and the World

Group	*SI (Number of species in India)*	*SW (Number of species in the World)*	*SI/SW (%)*
Mammals	372	4629	8.03
Birds	1228	9672	12.69
Reptiles	446	5680	7.85
Amphibians	204	5145	3.96
Fish	2546	21723	11.72
Flowering plants	17000	250000	6.80

Source

MoEF. 1997. National Action Plan on Biodiversity (draft). New Delhi: Ministry of Environment and Forests. Government of India.

Table 3

Threatened species of India

Taxonomic group	*Number of threatened species*
Mammals	75
Birds	73
Reptiles	16
Amphibians	3
Fish	4
Invertebrates	22

Source

IUCN 1996 Red list of threatened animal. IUCN, Gland, Switzerland.

Table 4

Atmospheric concentrations of greenhouse and ozone-depleting gases: 1965 to 1996

Year	*Carbon dioxide (PPM)*	*Carbon tetrachloride (PPT)*	*Methyl chloroform (PPT)*	*CFC-11 (PPT)*	*CFC-12 (PPT)*	*CFC-113 (PPT)*	*Total gaseous chlorine (PPT)*
Pre-industrial	280.0 *	—	—	—	—	—	—
1965	319.9	—	—	—	—	—	—
1966	321.2	—	—	—	—	—	—
1967	322.0	—	—	—	—	—	—
1968	322.9	—	—	—	—	—	—
1969	324.5	—	—	—	—	—	—
1970	325.5	—	—	—	—	—	—
1971	326.2	—	—	—	—	—	—
1972	327.3	—	—	—	—	—	—
1973	329.5	—	—	—	—	—	—
1974	330.1	—	—	—	—	—	—
1975	331.0	—	—	—	—	—	—
1976	332.0	—	—	—	—	—	—
1977	333.7	—	—	—	—	—	—
1978	335.3	88	58	139	257	—	1457
1979	336.7	88	63	147	272	—	1529
1980	338.5	90	71	158	289	—	1622
1981	339.8	91	76	166	305	—	1698
1982	341.0	93	82	175	325	26	1871
1983	342 6	94	86	182	341	28	1945
1984	344.3	95	89	190	355	31	2024
1985	345.7	97	93	200	376	36	2127
1986	347.0	98	97	209	394	40	2222
1987	348.8	100	100	219	411	48	2321
1988	351.3	101	104	231	433	53	2432
1989	352.8	101	108	240	452	59	2531
1990	354.0	102	111	249	469	66	2626
1991	355.5	102	114	254	483	71	2691
1992	356 3	101	118	260	496	77	2762
1993	357.0	101	113	260	502	79	2768
1994	358.9	101	108	261	509	81	2774
1995	360.9	99	97	261	519	82	2752
1996	362.6	99	89	261	522	82	2731

* approximately all estimates are by volume

PPM – parts per million, PPB – parts per billion; PPT – parts per trillion; CFC – chloroflourocarbon

Source

WRI 1999. World Resources 1998/99. Washington, DC: World Resources Institute

Table 5

Timetable of reductions from baseline levels

Chemical	*1987 Montreal Protocol*	*1990 London revisions*	*1992 Copenhagen revisions*	*1995 Vienna revisions (developing countries)*	*1997 Montreal revisions (developing countries)*
CFCs (chloroflourocarbons) 11,12 113, 114 115	Baseline 1986 freeze by 1989 20% by 1993 50% by 1998	Baseline 1986 freeze by 1989 50% by 1995 85% by 1997 100% by 2000	Baseline 1986 freeze by 1989 75% by 1994 100% by 1996	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Halons 1211 1301 2402	Baseline 1986 freeze by 1992	Baseline 1986 freeze by 1992 50% by 1995 100% by 2000	Baseline 1986 freeze by 1992 100% by 1994	Baseline 1995/97 freeze by 2002 50% by 2005 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Other CFCs	–	Baseline 1989 20% by 1993 85% by 1997 100% by 2000	Baseline 1989 20% by 1993 75% by 1994 100% by 1996	Baseline 1998/2000 20% by 2003 85% by 2007 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Carbontetrachloride	–	Baseline 1989 85% by 1995 100% by 2000	Baseline 1989 85% by 1995 100% by 1996	Baseline 1998/2000 85% by 2005 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Methylchloroform	–	Baseline 1989 freeze by 1993 30% by 1995 70% by 2000 100% by 2005	Baseline 1989 freeze by 1993 50% by 1994 100% by 1996	Baseline 1998/2000 freeze by 2003 30% by 2005 70% by 2010 100% by 2015	–
Hydrochloroflourocarbon	–	Mandatory reporting non-binding resolution on phase-out	Baseline 1989 freeze by 1996 35% by 2004 65% by 2010 90% by 2015 99 5% by 2020 100% by 2030	Baseline 2015 freeze by 2016 100% by 2040	–
Hydrobromofluorocarbons	–	–	100% by 1996	100% by 1996	–
Methylbromide	–	–	Baseline 1991 freeze by 1995	Baseline 1995/98 freeze by 2002 Developed countries baseline 1991 freeze by 1995 25% by 2001 50% by 2005 100% by 2010	baseline 1995/98 freeze by 2002 20% by 2005 100% by 2015 Developed countries baseline 1991 freeze by 1995 25% by 1999 50% by 2001 70% by 2003 100% 2005

Sources

1 Benedick RE 1998 Ozone diplomacy new directions in safeguarding the planet Cambridge. Harvard University Press

2 UNEP press backgrounder May 1999 ver 1 2 http.//www unep ch/ozone/press back

Table 6

Estimated production of ozone depleting substances (tonnes) for India

	1996	*2000*	*2005*	*2007*	*2010*
Chlorofluorocarbon-11	3420	2430	1250	200	0
Chlorofluorocarbon-12	4860	4000	790	170	0
Chlorofluorocarbon-113	740	630	250	120	0
Halon-1211	600	600	300	180	0
Halon-1301	340	340	170	100	0
Carbon tetrachloride	11660	13800	2590	960	0
Methylchloroform	1120	1050	530	40	0
Total	19190	16930	6110	910	0

Note

The table refers to production for indigenous consumption only and does not include exports.

Source

GoI. 1993. Country programme. 1993. Phase-out of ozone-depleting substances under the Montreal Protocol. New Delhi: Government of India.

Table 7

GHGs (greenhouse gases) and their main characteristics

	Carbon dioxide	*Methane*	*Nitrous oxide*	*CFC-12 (chlorofluorocarbon)*	*HCFC-22 (Hydrochlorofluorocarbon)(a chlorofluorocarbon substitute)*
GHG concentrations					
Pre-industrial concentration	280 PPMV	700 PPBV	275 PPBV	—	—
Concentration in 1992	356 PPMV	1714 PPBV	311 PPBV	268 PPTV	100 PPTV
Concentration in 1994	358 PPMV	1720 PPBV	312 PPBV §	268 PPTV §	110 PPTV
* Rate of concentration change	1.5 PPMV/year	10 PPBV/year	0.8 PPBV/year	0 PPTV/year	5 PPTV/year
	0 4%/year	0.6%/year	0.25/year	0%/year	5%/year
Atmospheric lifetime (years)	50–200 †	12 ‡	120	50	12
Global warming potential					
20 years	1	56 0 *	280	7900	4300
100 years	1	21.0	310	8500	1700
500 years	1	6.5	170	4200	520
Radiative forcing					
W/m² PPBV	1.8×10^{-5}	3.7×10^{-4}	$3\ 7 \times 10^{-}$	0.22	0.19
W/m²	1.56	0 5	0.1	0.1	0.02

PPMV – parts per million volume, PPBV – parts per billion volume; PPTV – parts per trillion volume

* the growth rates of carbon dioxide, methane, and nitrous oxide are averaged

§ estimated from 1992/93

† no single lifetime for carbon dioxide can be defined because of the different rates of uptake by different processes

‡ this has been defined as an adjustment time which takes into account the indirect effect of methane on its own lifetime

Sources

1. IPCC. Intergovernmental Panel On Climate Change. 1995 Climate Change 1994 – Radiative Forcing of Change and an Evaluation of the IPCC IS92 Emission Scenario. New York: Cambridge Unive
2. IPCC Intergovernmental Panel On Climate Change. 1996. Climate Change 1995 – The Science of Climate Change. Report of the IPCC Working Group I New York: Cambridge University Press.

For more details, please see TEDDY ONLINE+ [Section: GHGs (sources and sinks)]

Table 8

Global carbon dioxide emission estimates (million tonnes of carbon): 1970 to 1991

Item	*1970*	*1975*	*1980*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Total global emissions	**4083**	**4621**	**5292**	**5413**	**5601**	5726	**5954**	**6068**	**6098**	**6189**
Solid	1564	1679	1950	2239	2300	2351	2413	2454	2393	2342
Liquid	1838	2131	2407	2170	2276	2287	2394	2429	2482	2591
Gas	516	623	726	818	835	897	940	976	1004	1024
Cement	78	95	120	131	137	143	152	156	157	162
Gas flaring	87	93	89	55	53	48	55	53	62	70
Per capita emission of carbon (tonnes)	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.2

Source

ORNL 1994 Trends 93 A Compendium of Data on Global Change pp. 505–584 Tennessee, USA Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory 984 pp

For more details, please see TEDDY ONLINE+ [Section: GHGs (global data)]

Table 9

Carbon dioxide emission estimates (million tonnes of carbon) for India: 1970 to 1991

Item	*1970*	*1975*	*1980*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Total emissions	**53.3**	**69.1**	**95.5**	**134.3**	**143.6**	**152.1**	**163.8**	**178.4**	**184.3**	**192.0**
Solid	37.7	49.2	69.7	94.8	101.5	108.5	117.4	126.0	130.1	135.5
Liquid	13.1	16.7	22.4	31.4	32.9	33.7	35.3	39.3	39.6	41.4
Gas	0.3	0.5	0.7	2.0	2.8	3.2	3.5	4.2	5.2	5.3
Cement	1.8	2.2	2.4	4.5	5.0	5.0	5.5	6.3	6.7	6.8
Gas flaring	0.4	0.5	0.3	1.6	1.4	1.7	2.0	2.6	2.7	3.0
Per capita emissions (tonnes of carbon)	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Bunkers	0.5	0.5	0.7	0.5	0.6	0.7	0.9	0.8	0.7	0.7

bunkers refer to emissions expressed in million tonnes of carbon resulting from fuels consumed by ships and aircrafts engaged in international transportation
Emissions from bunker fuels are shown with the country where the fuel loading occurred but are not included in the national total

Source

Marland, Andres R J, and Boden T A. 1994 Global, regional, and national carbon dioxide emissions. pp 505–584 In T A Boden, D P Kaiser, R J Sepanski, F W Stoss (eds).

Table 10

Average annual budget of carbon dioxide perturbations: 1980 to 1989

	Sources and sinks	*Fluxes and reservoir changes of carbon*
	Carbon dioxide sources	
1	Emissions from fossil fuel combustion and cement production	5.5 ± 0.5
2	Net emissions from changes in tropical land use	1.6 ± 1.0
3	Total anthropogenic emissions	7.1 ± 1.1
	Partitioning among reservoirs	
4	Storage in the atmosphere	3.2 ± 0.2
5	Oceanic uptake	2.0 ± 0.8
6	Uptake by northern hemisphere forest regrowth	0.5 ± 0.5
	Other terrestrial sinks = (3) – (4) + (5) + (6) (carbon dioxide fertilization, nitrogen fertilization, climatic effects)	1.3 ± 1.5

Note

Fluxes and reservoir changes of carbon are expressed in gross tonnes of carbon per year; error limits correspond to an estimated 90% confidence interval.

Source

IPCC. Intergovernmental Panel on Climate Change. 1996. Climate Change 1995 – The Science of Climate Change. Report of the IPCC Working Group I New York: Cambridge University Press.

Table 11

Estimated sources and sinks of methane (Tg per year): 1980 to 1990

Sources and sinks	*Individual estimate*	*Total*
Observed atmospheric increase, estimated sinks and sources derived to balance the budget		
* Atmospheric increase		37 (35–40)
Sinks of atmospheric methane		
Tropospheric OH	490 (405–575)	
Stratosphere	40 (32–48)	
Soils	30 (15–45)	
Total atmospheric sinks		560 (460–660)
Implied total sources (sinks + atmospheric increase)		597 (495–700)
Inventory of identified sources		
Natural sources		160 (110–210) *
Anthropogenic		
Fossil fuel related	100 (70–120)	
Total biospheric	275 (200–350)	
Total anthropogenic sources		**375 (300–450)**
Total identified sources		**535 (410–660)**

* applies to 1980–90 average

Source

IPCC. Intergovernmental Panel on Climate Change. 1996.Climate Change 1995 – The Science of Climate Change. Report of the IPCC Working Group I New York: Cambridge University Press.

Table 12

Quantitative 2 × carbon dioxide damages in different world regions (2.5 °C warming)

Type of damage	*Damage indicator*	*European Union*	*USA*	*Former USSR*	*China*	*Non-OECD*	*OECD*	*World*
Agriculture	Welfare loss (%)	0.2	0.2	0.2	2.1	0.3	0.2	0.2
Forestry	Forest area lost (km²)	52.0	282.0	908.0	121.0	334.0	901.0	1235.0
Fishery	Reduced catch ('000 tonnes)	558 0	452.0	814.0	464.0	4326.0	2503.0	6829.0
Energy	Rise in electricity demand (TWh)	54.2	92.0	54.6	17.1	142.7	211.2	353.9
Water	Reduced water availability (km²)	15 3	32.7	24.7	32.2	168.5	62.2	230.7
Coastal protection	Annual capital costs (million dollars/year)	133.0	176.0	51.0	24.0	51.4	493.0	1007.0
Dryland loss	Area lost ('000 km²)	1.6	10.7	23.9	—	99.5	40.4	139.9
Wetland loss	Area lost ('000 km²)	9.9	11.1	9.8	11.9	219.1	33.9	253.0
Ecosystems loss	Number of protected habitats lost Assuming 2% loss	16.0	8.0		4.0	53.0	53.0	106.0
Health/mortality	Number of deaths ('000)	8.8	6.6	7.7	29.4	114.8	22.9	137.7
Air pollution	Equivalent increase in emissions	566.0	1.1	1.6	227.0	2602.0	1943.0	4545.0
Troposphere	('000 tonnes nitrogen oxide)	285.0	422.0	1.1	258.0	1864.0	873.0	2737.0
Sulphur dioxide	('000 tonnes sulphur)							
Migration	Additional immigrants ('000)	229.0	100.0	153.0	583.0	2279.0	455.0	2734.0
Hurricanes								
Casualties	Number of deaths	—	72.0	44.0	779.0	7687.0	313.0	8000.0
Damages	Million dollars	—	115.0	1.0	13.0	124.0	506.0	630.0

OECD – Organization for Economic Cooperation and Development

Source

IPCC. Intergovernmental Panel on Climate Change. 1996. Climate Change 1995 – The Economic and Social Dimensions of Climate Change. Report of IPCC Working Group III. New York: Cambridge University Press.

Table 13

Aggregate monetary damage for 2 × carbon dioxide (annual damages)

Region	Damage / GDP (%) *
Developed countries (Organization for Economic Cooperation and Development)	1–2
Developing countries with economies in transition	2–9
World	1.5–2

* Gross domestic product corrected for differences in purchasing power parity

Source
IPCC. (Intergovernmental Panel on Climate Change) 1996. Climate Change 1995 – The Science of Climate Change. Report of the IPCC Working Group I. New York: Cambridge University Press

Table 14

Effect of 1-m sea-level rise on coastal area and population

State/union territory	Coastal area (million hectares)			Population (million hectares)		
	Total	*Inundated*	*Percentage*	*Total*	*Affected*	*Percentage*
Andhra Pradesh	27.50	0.06	0.19	66.36	0.62	0.93
Goa	0.37	0.02	4.34	1.17	0.09	7.25
Gujarat	19.60	0.18	0.92	41.17	0.44	1.07
Karnataka	19.18	0.03	0.15	44.81	0.25	0.56
Kerala	3.89	0.01	0.30	29.08	0.45	1.56
Maharashtra	30.77	0.04	0.13	78.75	1.38	1.75
Orissa	15.57	0.05	0.31	31.51	0.56	1.76
Tamil Nadu	13.01	0.07	0.52	55.64	1.62	2.91
West Bengal	8.88	0.12	1.38	67.98	1.60	2.35
Union territory						
Andaman and Nicobar Islands	0.83	0.01	0.72	—	—	—
India	**139.59**	**0.57**	**0.41**	**416.74**	**7.10**	**1.68**

Note
Coastal area and population are based on the 1981 and 1991 censuses.

Source
JNU. 1993 Impact of greenhouse induced sea-level rise on the islands and coasts of India New Delhi Department of Environment and Forests, Jawaharlal Nehru University

Table 15

Impact of 1-m sea-level rise on coastal districts (billion 1990 rupees) (4.5% rate of growth, 5% discount rate)

Coastal areas	*Economic impact*	*Value of anticipation*	*Cost of protection*
Mumbai	2287.0	1061.0	0.8
Goa	81.0	36.5	1.4
Balasore	3.6	1.3	1.3

Source
TERI 1996 The economic impact of a 1-m sea-level rise on the Indian Coastline. method and case studies Report submitted to Ford Foundation

Table 16

Regionwise emissions of greenhouse gases from various anthropogenic sources: 1991

	Carbon dioxide emissions (thousand tonnes)						Methane emissions (thousand tonnes)								
Region	*Solid*	*Liquid*	*Gas*	*Gas flaring*	*Cement manufacture*	*Total*	*Bunker fuels*	*Land-use change*	*Solid wastes*	*Coal mining*	*Oil and gas production*	*Wet rice agriculture*	*Livestock*	*Total*	*CFC (thousand tonnes)*
Africa	271744	255487	63028	54335	25138	671600	10102	640000	1400	1600	1000	2600	9600	16000	12
South Africa	239138	33276	—	—	3736	278695	10102	—	180	1500	—	1	920	2600	5
Zimbabwe	15664	1729	—	—	348	16983	—	4100	23	44	—	—	230	300	—
Asia	3660255	2546227	415410	112820	282563	6671525	50332	920000	8200	17000	3200	67000	25000	120000	100
China	2088011	365118	30778	—	123411	2543380	—	—	880	14000	250	19000	5400	40000	8
India	551897	151583	19540	10968	24915	703550	2689	21000	2300	1800	160	19000	12000	35000	3
Japan	317790	619476	106278	—	44449	1091147	21141	—	1900	97	35	1400	280	3600	64
North and Central America	1920511	2527207	1240792	18369	57488	5764359	71950	190000	10000	9800	6500	980	8800	36000	100
USA	1803838	2034044	1052125	7453	34174	4931630	67418	22000	8400	9100	5300	750	6000	29000	90
Canada	94696	178078	127866	4507	5481	410628	4532	—	1200	630	800	—	740	3300	8
South America	68601	364136	119681	17556	24996	594986	—	1600000	1900	270	970	820	14000	18000	10
Brazil	39879	153009	7310	2444	12956	215601	—	970000	1100	3	59	330	8300	8300	4
Colombia	16158	29418	7929	809	3189	57503	—	100000	140	220	64	260	910	1600	1
Europe	1696520	1600516	663866	29041	123816	4113771	118758	—	15000	3400	2600	240	7700	29000	120
Germany	507548	307926	132091	1137	20930	969630	—	—	1300	730	250	—	770	3000	23
UK	251402	216084	99745	3944	5981	577157	18954	—	1300	1100	480	—	910	3800	17
Former Soviet Union	1105766	1216320	1172733	23074	63288	3581179	—	—	2600	6300	11000	320	7900	28000	44
Oceania	154562	89321	41103	—	3783	288767	6295	29000	630	1500	400	66	3000	5600	6
World	**8581088**	**9493424**	**3751936**	**256480**	**593568**	**22672832**	— *	**3400000**	**40000**	**40000**	**26000**	**72000**	**76000**	**250000**	**400**

CFC – chloroflourocarbon

bunker fuels are included in the world total of fuel type

Source

WRI 1994 A Report by the World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme, 1994/95 pp 362–365 New York Oxford University Press and the World Resources Institute

For more details, please see TEDDY ONLINE + [Section GHG (global data)]

Table 17

Top ten greenhouse gas emitters

Country	*Percentage of total emissions*
USA	19.1
Former USSR	13.6
China	9.9
Japan	5.1
Brazil	4.3
Germany	3.8
India	3.7
UK	2.4
Indonesia	1.9
Italy	1.7

Note

Data refer to 1991

Source

WRI. 1995. World Resources, 1994/95. Washington, DC: World Resources Institute.

Table 18

India's national greenhouse gases inventory for 1990 (Gg)

Greenhouse gas sources and sinks	*Carbon dioxide emissions*	*Carbon dioxide removals*	*Methane*	*Nitrous oxide*	*Oxides of nitrogen*	*Carbon monoxide*	*Carbon dioxide equivalent Carbon dioxide +methane+nitrous oxide) ‡*
Energy							
Fuel combustion							
Energy and transformation industries	508600	—	—	—	—	—	508600
Industry	—	—	—	—	—	—	—
Transport	57300	—	—	—	2684	3493	—
Small combustion	—	—	—	—		—	—
Traditional biomass burnt	300460 *	—	1579	11	400	11472	36569
Fugitive emissions from fuels							—
Solid fuels	—	—	330	—	—	—	6930
Oil and natural gas	—	—	628	—	—	—	13188
Total emissions from energy sector (fuel combustion + fugitive)	565900	—	2537	11	3084	14965	565287
Industrial processes	24200	—	—	1	—	—	24510
Solvent and other products							
Agriculture							
Enteric fermentation	—	—	6807	—	—	—	142947
Manure management	—	—	905	—	—	—	19005
Rice cultivation	—	—	4070 †	—	—	—	85470
Agricultural soils	—	—	—	240	—	—	74400
Prescribed burning of savannas	—	—	—	—	—	—	—
Field burning of agricultural residues	—	—	116	3	109	3040	3366
Total emissions from agricultural sources			11898	243	109	3040	325188
Land-use change and forestry							
Change in forests and other woody biomass stock	—	–6233	—	—	—	—	–6233
Forests and grassland conversion	52066	—	—	—	—	—	52066
Abandonment of managed lands	—	–44366	—	—	—	—	–44366
Total emissions from land-use change and forestry sector	52066	-50599	—	—	—	—	1467
Waste							
Solid waste disposal on land	—	—	334	—	—	—	7014
Domestic and commercial waste water	—	—	49	—	—	—	1029
Industrial waste water	—	—	2905	—	—	—	61005
Other waste	—	—	—	—	—	—	—
Total emissions from waste	—	—	3288	—	—	—	69048
Total national emissions and removals	**584866**	**-50599**	**17723**	**255**	**3193**	**18005**	**985140**

* carbon dioxide emissions from biomass burning are not included in the national totals

† methane emissions according to IPCC (Intergovernmental Panel on Climate Change) 1996 methodology

‡ carbon dioxide equivalents are based on the GWP (global warming potential) of 21 for methane and 310 for nitrogen oxide, nitrous oxide and carbon dioxide are not included since the GWP have not been developed for these gases Banker fuel emissions are not included in the national total

Source

TERI 1998 India National Report on ALGAS (Asia–Least–Cost Greenhouse Gas Abatement Strategy). New Delhi: Tata Energy Research Institute

Table 19

Emissions reductions below 1990 levels (%) proposed in the first draft and the final Kyoto Protocol

Party	First draft (2006–10)	Final (2008–12)
Australia	+5	+8
Austria	8	–8
Belgium	–8	–8
Bulgaria	–8	–8
Canada	–5	–6
Croatia	–5	–5
Czech Republic	–8	–8
Denmark	–8	–8
Estonia	–8	–8
EU	–8	–8
Finland	–8	–8
France	–8	–8
Germany	–8	–8
Greece	–8	–8
Hungary	–8	–6
Iceland	+10	+10
Ireland	–8	–8
Italy	–8	–8
Japan	–4.5	–6
Latvia	–8	–8
Liechtenstein	–8	–8
Lithuania	–8	–8
Luxembourg	–8	–8
Monaco	–8	–8
The Netherlands	–8	–8
New Zealand	0	0
Norway	+5	+1
Poland	–8	–6
Portugal	–8	–8
Romania	–8	–8
Russian Federation	–5	0
Slovakia	–8	–8
Slovenia	–8	–8
Spain	–8	–8
Sweden	–8	–8
Switzerland	–8	–8
Ukraine	–5	0
UK	–8	–8
USA	–5	–7

Source

FCCC Secretariat. 1997. Framework Convention on Climate Change (FCCC) Secretariat. FCCC/CP/1997/CRP 4 (9 December 1997) Bonn. The FCCC Secretariat.

Table 20

Average annual emissions (tonnes) of carbon dioxide due to fossil fuels: 1990

Region	*Per capita emissions*	*Emissions per GDP* * *(per '000 1990 US$ output)*	*Emissions per GDP* † *(per '000 1990 US$ output)*
Global	1.1	0.30	– *
Developed and transitional economies	2.8 (1.5–5.5)	0.27	0.26
Developing countries	0.5	0.41	0.16

using World Bank estimates of GDP (gross domestic product) at market exchange rates

using World Bank estimates of GDP at purchasing power parity

Source

IPCC. Intergovernmental Panel on Climate Change. 1996. Climatic Change 1995 – The Economic and Social Dimensions of Climate Change. Report of the IPCC Working Group III. New York: Cambridge University Press.

Table 21

Cost of various carbon dioxide mitigation options for India

Technology	*Greenhouse gas emissions reduction*	*Investment cost*	*Cost effectiveness (dollars/tonne carbon dioxide)*
Transport sector			
CNG (compressed natural gas) car	0.017 kg/P-km	10965 dollars/unit	4500
CNG bus	0.41 kg/P-km	31000 dollars/unit	12
Mass rapid transport system	–	1.4 billion dollars	–
BOV (battery-operated vehicle) (three wheeler)	–	2444 dollars/unit	–
Two-wheeler (four-stroke)	0.0014 kg/P-km	1156 dollars/unit	30000
Renewable energy for power			
Small hydro	1.3 kg/kWh	1950 dollars/kW	88
Wind farms	1.3 kg/kWh	1405 dollars/kW	257
Biomass	1.6 kg/kWh	710 dollars/kW	102
Solar thermal	1.3 kg/kWh	3730 dollars/kW	592
Solar photovoltaic (PV)	1.6 kg/kWh	5952 dollars/kWp	541
Agriculture sector			
Agro-based gasifier	1.6 kg/kWh	760 dollars/kW	119
Wood-based gasifier	1.6 kg/kWh	694 dollars/kW	115
Wind-based shallow pumping	1.6 kg/kWh	1157 dollars/kW	173
Wind-based deep wells	1.6 kg/kWh	2149 dollars/kW	176
PV pump	1.6 kg/kWh	8598 dollars/kWp	1602
Power generation			
Cogeneration	1.50 kg/kWh	900 dollars/kW	10
Combined cycle	0.96 kg/kWh	818 dollars/kW	54
Inter-cooled steam injected gas turbine	0.76 kg/kWh	947 dollars/kW	77
Pressurized fluidized bed combustion	0.18 kg/kWh	1894 dollars/kW	503
Integrated gasification combined cycle	0.23 kg/kWh	1578 dollars/kW	340
Pulverized coal super-critical boilers	0.18 kg/kWh	1202 dollars/kW	342
Coal washing	0.125 kg/kWh	11 dollars/tonne a year	179
Domestic lighting			
Compact fluorescent lamps	6.49 Tg/year	8 dollars/unit	–
36 W fluorescent	0.09 Tg/year	0.9 dollars/unit	–

P-km - passenger-kilometre

Source

ADB 1998 Asia Least-cost Greenhouse Gas Abatement Strategy Manila, Philippines Asian Development Bank

Appendix I

Disaggregation of data by sector in **Teddy Online+**
[***The new WIN-WEB version of the database is available on floppies.***]

Energy supply

Coal	General Production Closing stock Prices and unit values Transport Plan statistics	Reserves Despatches Offtake Trade International data
Oil and gas	General Refining – capacity and throughput, stocks Transportation Exports and imports Financial structure and resources Plan statistics	Exploration, reserves, and production Sales and consumption Marketing network Prices Sales tax and excise/custom duties International – reserves, production, consumption, refining, trade, gas liquefaction, prices
Power	Capacity and generation – thermal, utility, hydro, nuclear, captive State electricity boards Rural Human resources Plan statistics	Load survey Utilization Transmission Finance – subsidy, costs and revenues, tariff Power development International data
Renewables	Actual and potential Solar Wind Fiscal/promotional incentives International data	Biogas Hydro Tidal Plan statistics
Forests	Land utilization Afforestation and regeneration Imports and exports Non-forest data Macro- and state-level data Externally aided projects International data	Forest cover Forest area lost Forest out-turn and inventory National parks Trade Plan statistics

Energy demand

Agriculture	Area, yield, and production Stocks Fertilizers, pesticides, and other inputs Rainfall and drought Labour force Prices Aquaculture and fish International data	Procurement Land-related statistics Irrigation-related statistics Mechanization Livestock Infrastructure Outlays and expenditure Agriculture and national income
Industrial	General Soda ash Fertilizers Sugar	Aluminium Cement Iron and steel Textiles
Residential	General Production of appliances	Fuel/energy consumption
Transport	General Railways Water transport	Roads and road transport Air transport Inland water transport

Environment

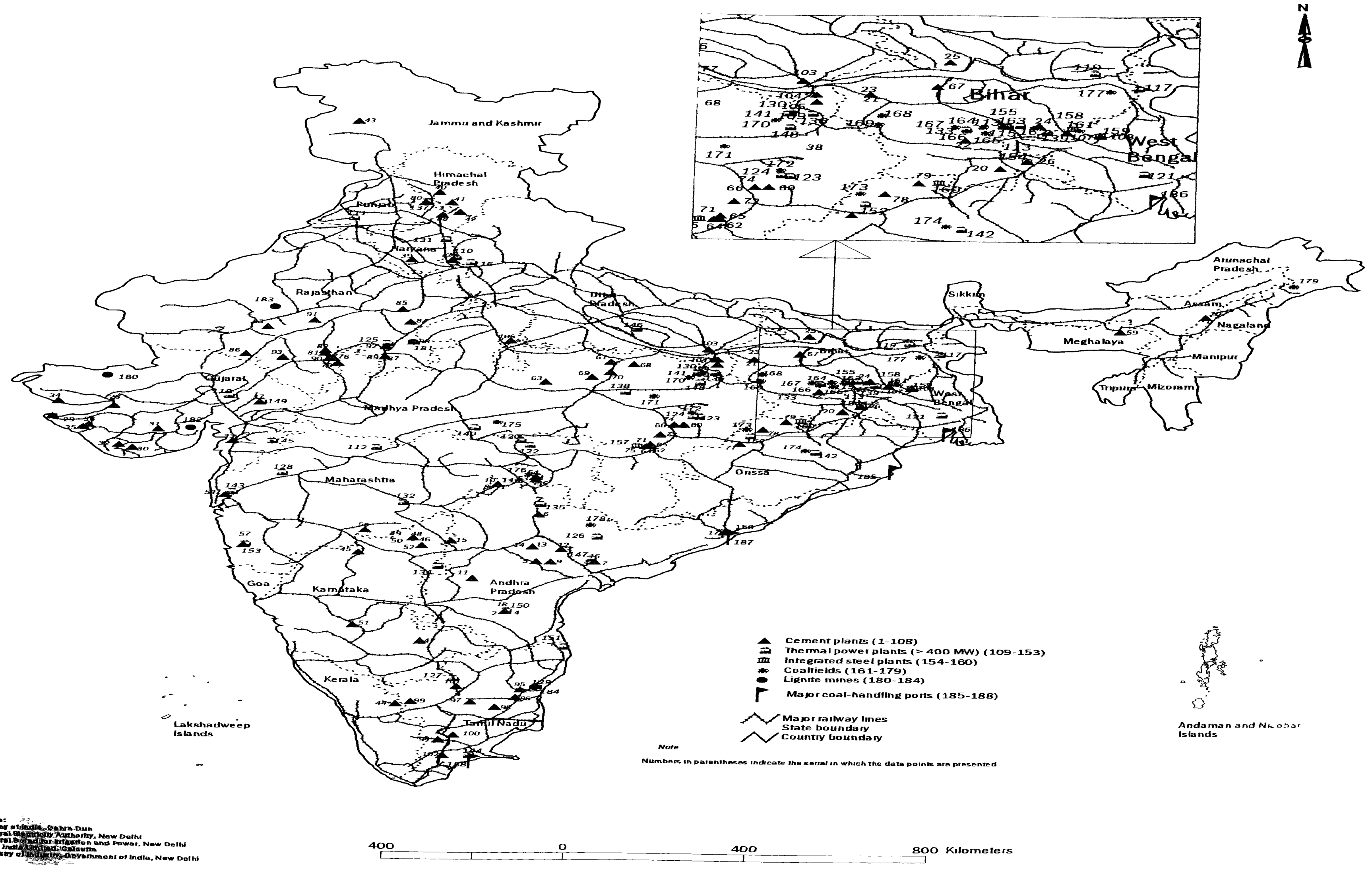
Local environment	Air emissions – general, industry, power, refineries, transport, domestic General impact on health International data	Water emissions – general, industry Solid wastes Noise Plan statistics
Global environment	Sources and sinks Mitigation technologies Selected countries emission profile	Impacts Global data

Economy

Economic indicators	General Macro aggregates Trade, investment, and balance of payments Miscellaneous Linkages with energy	Demographic statistics Subsidies Debt Prices Plan statistics International data

Appendix II

Map 1. Coalfields and coal consuming industries (August 1999)
Map 2. HBJ (Hazira–Bijapur–Jagdishpur) gas transmission system
Map 3. Crude pipelines
Map 4. Product pipelines
Map 5. Major power generating units of India (August 1999)
Map 6. Powergrid map of India (August 1999) (400 kV and above)
Map 7. Forest cover in India by state (August 1999)



Source:
1. Survey of India, Dehra Dun
2. Central Electricity Authority, New Delhi
3. Central Board for Irrigation and Power, New Delhi
4. Coal India Limited, Calcutta
5. Ministry of Industry, Government of India, New Delhi

Map 1. Coalfields and coal consuming industries (August 1999)

Map 1. Data

Cement plants: location and capacity

Sl no.	Cement plants	Location	Capacity (thousand tonnes)
1	Cement Corporation of India (CCI) Ltd	Adilabad, Andhra Pradesh	400
2	India Cements	Chilamkur, Andhra Pradesh	1000
3	Madras Cements	Jayantipuram, Andhra Pradesh	1100
4	Juari Cements	Yerraguntla, Andhra Pradesh	500
5	KCP Cements	Macherla, Andhra Pradesh	400
6	Kesoram Cements	Basant Nagar, Andhra Pradesh	900
7	Kistna Cements	Vijayawada, Andhra Pradesh	214
8	ACC Ltd	Mancherial, Andhra Pradesh	335
9	Andhra Cements	Nadikudi Durga, Andhra Pradesh	500
10	Orient Cements	Mancherial, Andhra Pradesh	1180
11	Panyam Cements	Bugganipalle, Andhra Pradesh	531
12	Priyadarsani Cements	Kodad, Andhra Pradesh	600
13	Rassi Cements	Vishnupuram, Andhra Pradesh	1600
14	Sri Vishnu Cements	Dondapadu, Andhra Pradesh	1000
15	CCI Ltd	Tandur, Andhra Pradesh	1000
16	Andhra Cements	Vijayawada, Andhra Pradesh	240
17	Andhra Cements	Vizag, Andhra Pradesh	500
18	Andhra Cements	Yerraguntla, Andhra Pradesh	400
19	CCI Ltd	Bokajan, Assam	200
20	ACC Ltd	Chaibasa, Bihar	635
21	Kalyanpur Cements	Banjari, Bihar	1000
22	Khalari Cements	Khalari, Bihar	109
23	Rohtas Cements	Rohtas, Bihar	620
24	ACC Ltd	Sindri, Bihar	305
25	Sone Valley Cements	Japla, Bihar	254
26	TISCO	Jojobera, Bihar	1430
27	CCI Ltd	Delhi, Delhi	500
28	Shri Digvijay Cements	Digvijaygram, Gujarat	1025
29	Dwarka Cements	Dwarka, Gujarat	277
30	Gujarat Ambuja Cements	Kodinar, Gujarat	3000
31	L&T Cements	Gujarat Cem Proj, Gujarat	1500
32	Gujarat Sidhee Cements	Tal-Veraval, Gujarat	1200
33	Narmada Cements	Magdalla, Gujarat	667
34	Tata Chemicals	Mithapur, Gujarat	440
35	Porbandar Cements	Porbandar, Gujarat	198
36	Saurashtra Cements	Ranavav, Gujarat	1164
37	Sevalia Cements	Sevalia, Gujarat	215
38	ACC Ltd	Bhupendra, Haryana 257	
39	CCI Ltd	Charkhi Dadri, Haryana	172
40	ACC Ltd	Gagal, Himachal Pradesh	1938
41	Gujarat Ambuja Cements	Darlaghat, Himachal Pradesh	960
42	CCI Ltd	Rajban, Himachal Pradesh	200
43	J&K Cements	Khrew, Jammu and Kashmir	200
44	Malabar Cements	Walayar, Kerala	420
45	Kanoria Cements	Bagalkot, Karnataka 330	
46	CCI Ltd	Kurkunta, Karnataka200	
47	Mysore Cements	Amasandra, Karnataka	570
48	Rajashree Malkhed Cements	Malkhed, Karnataka 2000	
49	HMP Group Cements	Shahabad, Karnataka	476
50	Vasavadatta Cements	Sedam, Karnataka	500
51	Visvesvaraya Cements	Visvesvaraya, Karnataka	100
52	ACC Ltd	Wadi, Karnataka	1950
53	L&T Cements	Awarpur, Maharashtra	2550
54	ACC Ltd	Chanda, Maharashtra	620

Continued...

Sl no.	Cement plants	Location	Capacity (thousand tonnes)
55	Manikgarh Cements	Korpana, Maharashtra	1500
56	Rajashree Hotgi Cements	Hotgi, Maharashtra	1200
57	Narmada Cements	Ratnagiri, Maharashtra	333
58	Shree Digvijay Cements	Sewree, Maharashtra	200
59	Mawmluh Cements	Mawmluh, Meghalaya	200
60	CCI Ltd	Akaltara, Madhya Pradesh	400
61	Birla Vikas Cements	Satna, Madhya Pradesh	1550
62	Century Cements	Baikunth, Madhya Pradesh	1200
63	Diamond Cements	Narsingarh, Madhya Pradesh	1025
64	Grasim Cements	Grasim Vihar, Madhya Pradesh	1700
65	L&T Cements	Himri, Madhya Pradesh	1400
66	ACC Ltd	Jamul, Madhya Pradesh	1580
67	Jaypee Bela Cements	Bela, Madhya Pradesh	1500
68	Jaypee Rewa Cements	Jaypee Nagar, Madhya Pradesh	2500
69	ACC Ltd	Kymore, Madhya Pradesh	1200
70	Birla Group Cements	Maihar, Madhya Pradesh	2000
71	CCI Ltd	Mandhar, Madhya Pradesh	380
72	Modi Cements	Modigram, Madhya Pradesh	1800
73	CCI Ltd	Neemuch, Madhya Pradesh	400
74	Raymond Cements	Gopal Nagar, Madhya Pradesh	2240
75	TISCO	Sonadih, Madhya Pradesh	300
76	Vikram Cements	Vikram Nagar, Madhya Pradesh	2500
77	IDCOL	Bardol, Orissa	960
78	L&T Cements	Jharsuguda, Orissa	700
79	OCL India	Rajgangpur, Orissa	1001
80	Gujarat Ambuja Cements	Ropar, Punjab	1040
81	Aditya Cements	Shambhupura, Rajasthan	1000
82	Birla Group Cements	Chittor, Rajasthan	1400
83	DLF Cements	Rabriyawas, Rajasthan	1400
84	Jaipur Udyog Cements	Sawai Madhopur, Rajasthan	1000
85	ACC Ltd	Lakheri, Rajasthan	322
86	JK Group Cements	Lakshmi, Rajasthan	2230
87	Mangalam Cements	Morak, Rajasthan	400
88	Cement Works(G)	Mangrol, Rajasthan	210
89	Neer Shree Cements	Morak, Rajasthan	700
90	JK Group Cements	Nimbahera, Rajasthan	1540
91	Shree Digvijay Cements	Bangur Nagar, Rajasthan	3500
92	Sriram Cements	Sriramnagar, Rajasthan	200
93	JK Group Cements	Udaipur, Rajasthan	900
94	Tamil Nadu Cement Corporation	Alangulam, Tamil Nadu	400
95	Madras Cements	Althiyur, Tamil Nadu	900
96	Tamil Nadu Cements Corporation	Ariyalur, Tamil Nadu	500
97	Chettinad Cements	Puliyur, Tamil Nadu	600
98	Dalmia Cements	Dalmiapuram, Tamil Nadu	525
99	ACC Ltd	Madukkarai, Tamil Nadu	730
100	Madras Cements	Ramasamyraja, Tamil Nadu	750
101	India Cements	Sankaridurg, Tamil Nadu	600
102	India Cements	Shankarnagar, Tamil Nadu	1100
103	UP State Cement Corporation	Chunar, Uttar Pradesh	1680
104	UP State Cement Corporation	Churk, Uttar Pradesh	475
105	UP State Cement Corporation	Dalla, Uttar Pradesh	432
106	Diamond Jhansi Cements	Jhansi, Uttar Pradesh	500
107	Damodar Cements	Madhukunda, West Bengal	270
108	Durgapur Cements	Durgapur, West Bengal	600

Thermal power plants (coal-based): location and capacity

Sl no.	Location	Capacity (MW)
109	Anpara	1630
110	Badarpur	420
111	Bhatinda GNDT	440
112	Bhusawal	420
113	Bokaro A&B	630
114	Chandrapur STPS	1840
115	Chandrapura (Bihar)	620
116	Dadri	840
117	Farakkaha STPS	1600
118	Gandhinagar	660
119	Khalgaon	840
120	Khaparkheda	420
121	Kolaghat	1260
122	Koradi	880
123	Korba STPS	2100
124	Korba West	840
125	Kota	850
126	Kothagudem	430
127	Mettur	840
128	Nasik	910
129	Neyveli	1770
130	Obra	1000
131	Panipat	750
132	Parli	630
133	Patratu	430
134	Raichur	440
135	Ramagundam	2100
136	Rihand	2000
137	Ropar	1050
138	Sanjay Gandhi	420
139	Santhaldih	480
140	Satpura Sarni	830
141	Singrauli STPS	1000
142	Talcher	1220
143	Trombay	1150
144	Tuticorin	1050
145	Ukai	850
146	Unchahar	420
147	Vijaywada	1260
148	Vindhyachal	1260
149	Wanakbori	1260
150	Cuddapah	420
151	North Chennai	630
152	Ib Valley	420
153	Dhanu	500

Location of iron and steel industries

Sl no.	Location
154	Jamshedpur
155	Bokaro
156	Vishakhapatnam
157	Bhilai
158	Burnpur (IISCo)
159	Durgapur
160	Rourkela

Location of major coalfields

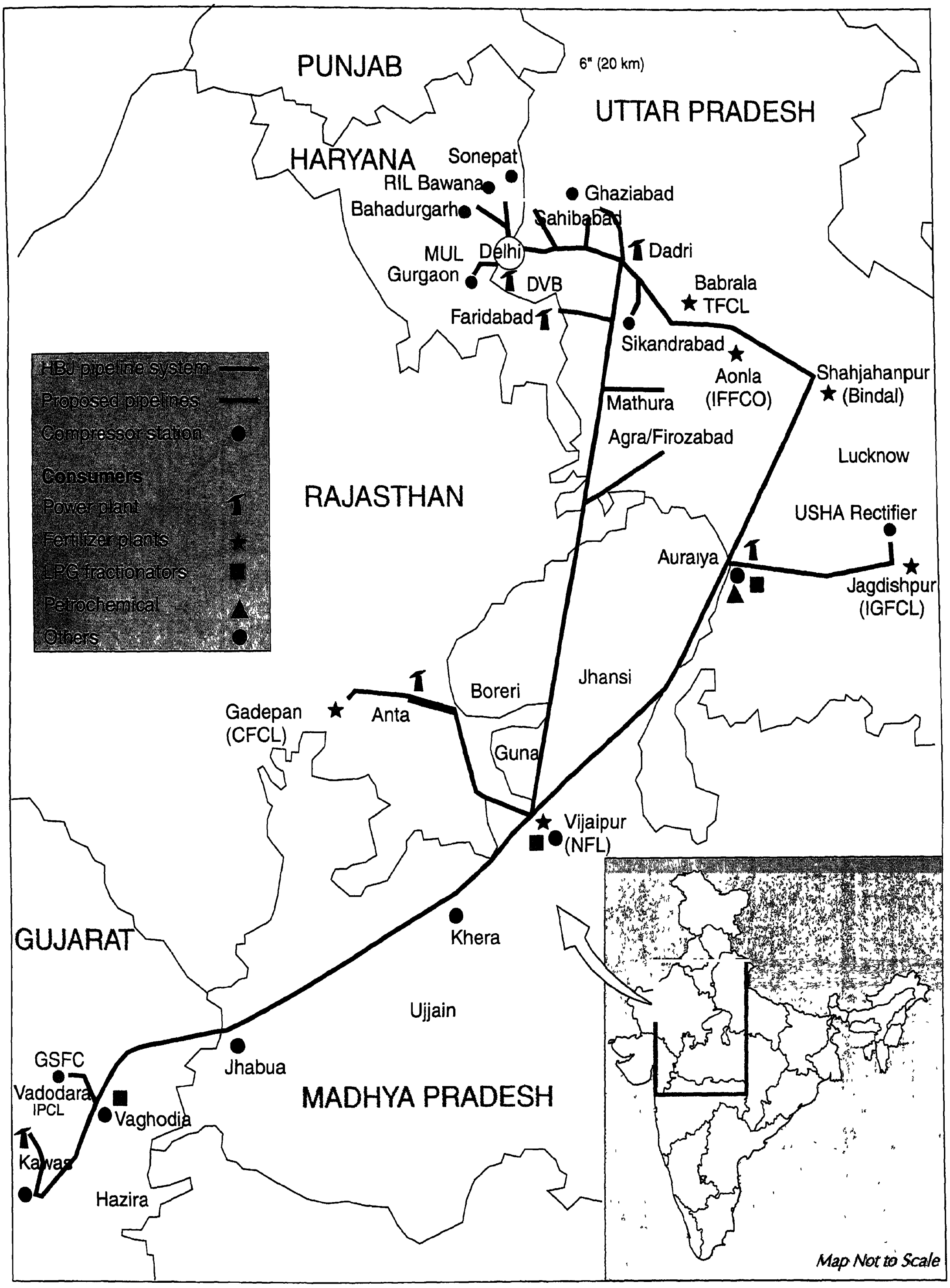
Sl no.	Location
161	Ranigunj
162	Jharia
163	East Bokaro
164	West Bokaro
165	Ramgarh
166	South Karanpura
167	North Karanpura
168	Daltonganj
169	Hutar
170	Singrauli
171	Sohagpur
172	Korba
173	Ib river
174	Talcher
175	Pench-Kanhan
176	Wardha valley
177	Rajmahal
178	Gadavari
179	Makum, Namchik-Namphuk

Location of lignite mines

Sl no.	Location
180	Padundaro, Gujarat
181	Mangrol, Rajasthan
182	Bhavnagar, Gujarat
183	Birsinghpur, Rajasthan
184	Neyveli, Tamil Nadu

Location of major coal handling ports

Sl no.	Location
185	Paradip
186	Haldia
187	Vishakhapatnam
188	Tuticorin

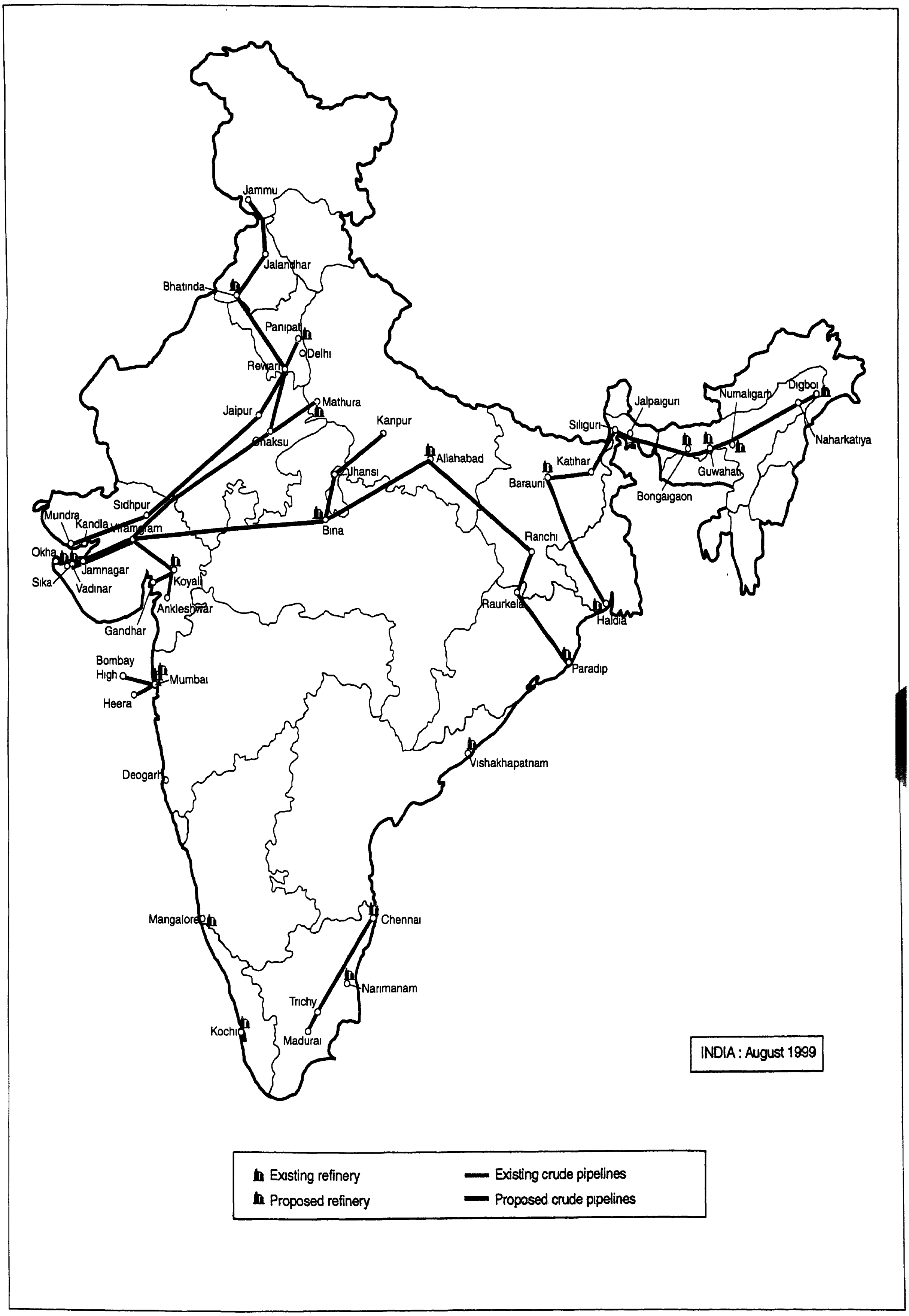


INDIA· August 1999

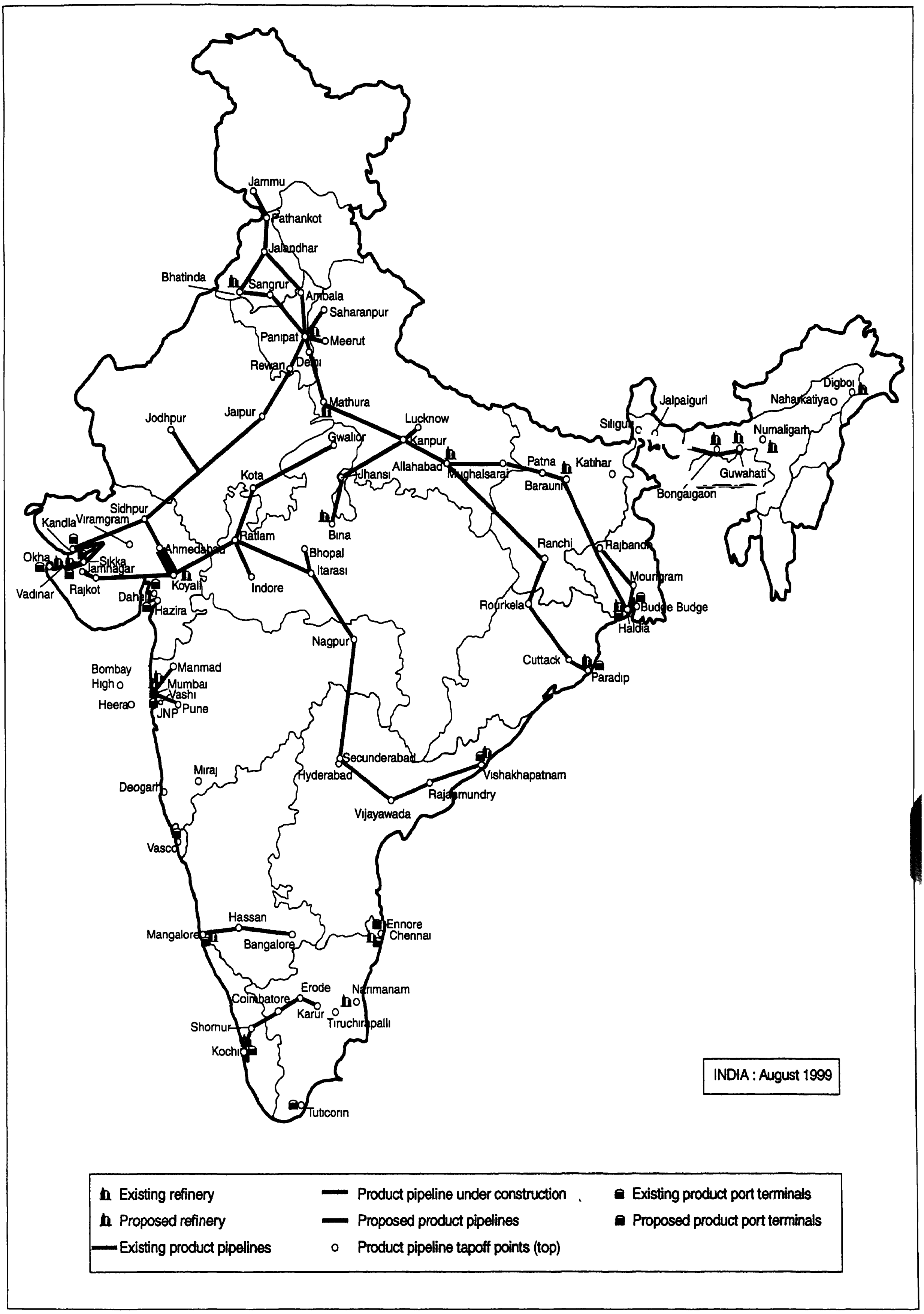
Source
Gas Authority of India Limited

CFCL - Chambal Fertilizers and Chemicals Ltd
DVB - Delhi Vidyut Board
GSFC - Gujarat State Fertilizer Corporation
IFFCO - Indian Farmers Fertilizers Co-operative
IGFCC - Indo-Gulf Fertilizers and Chemicals Corporation
IPCL - Indian Petrochemicals Ltd
MUL - Maruti Udyog Ltd
RIL - Reliance Industries Ltd
TFCL - Tata Fertilizers and Chemicals Ltd

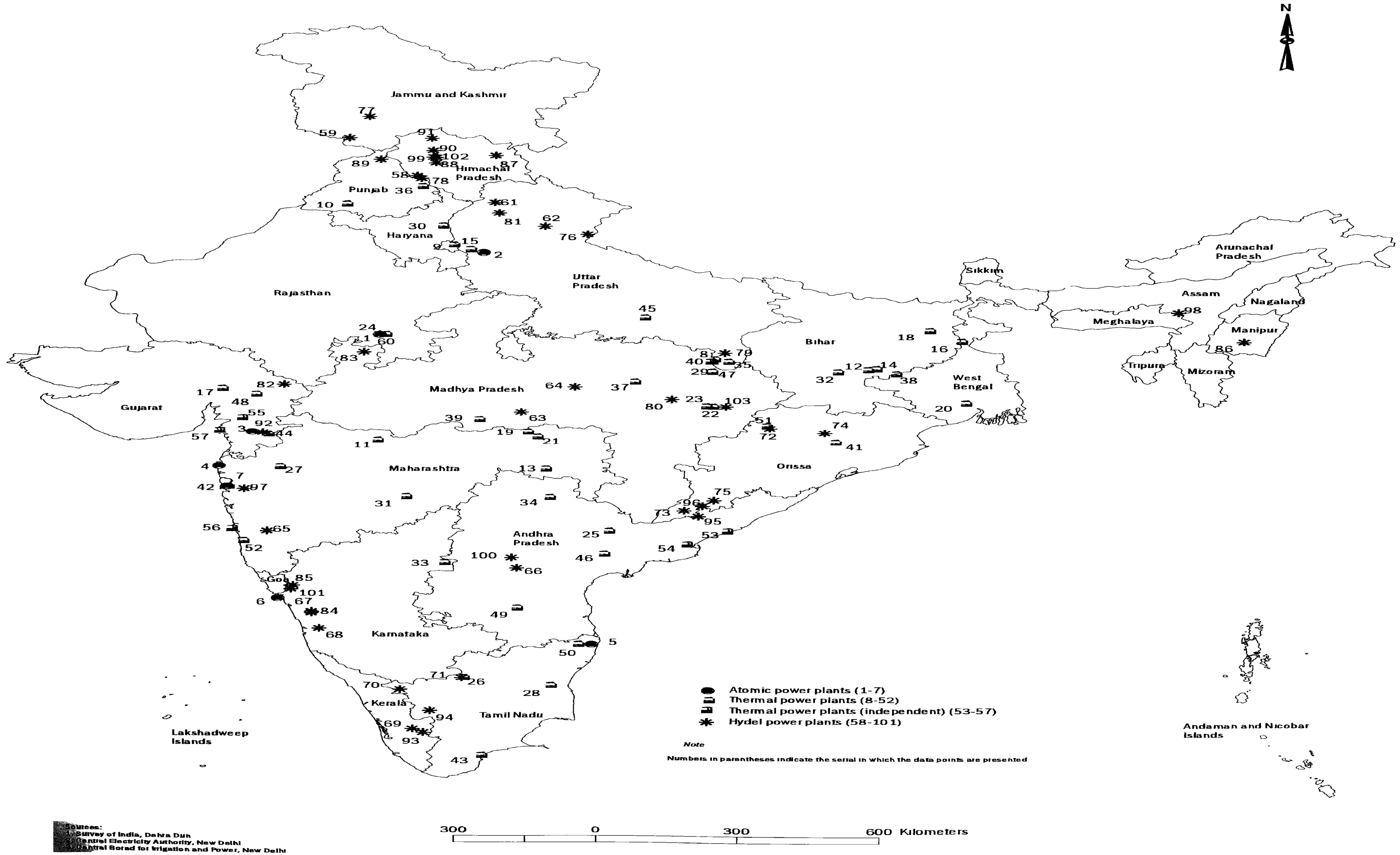
Map 2. HBJ (Hazira–Bijapur–Jagdishpur) gas transmission system



Map 3. Crude pipelines



Map 4. Product pipelines



Note

Numbers in parentheses indicate the serial in which the data points are presented

Sources:
1. Survey of India, Dehra Dun
2. Central Electricity Authority, New Delhi
3. Central Borad for Irrigation and Power, New Delhi

Map 5. Major power generating units of India (August 1999)

Map 5. Data

Location of nuclear plants

Sl no.	Location
1	RAPS, Kota
2	Narora, Bulandshahr
3	Kakrapar, Mandvi
4	Tarapur, Thane
5	Kalpakkam, Chennai
6	Kaiga, Karwar
7	Trombay, Mumbai

Thermal power plants: location and capacity

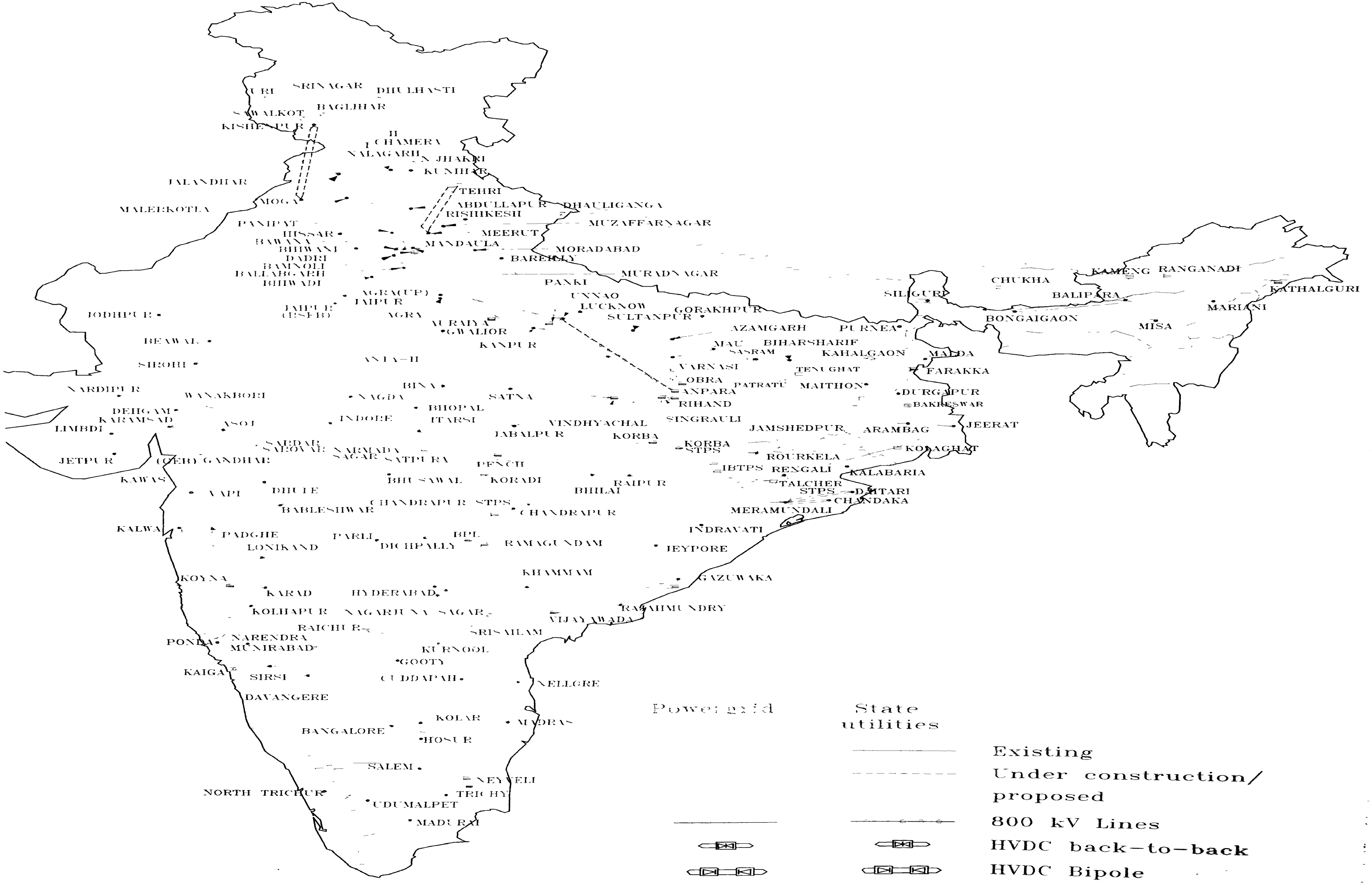
Sl no.	Location	Capacity (MW)
8	Anpara	1630
9	Badarpur	420
10	Bhatinda GNDT	440
11	Bhusawal	420
12	Bokaro A&B	630
13	Chandrapur STPS	1840
14	Chandrapura (Bihar)	620
15	Dadri	840
16	Farakkaha STPS	1600
17	Gandhinagar	660
18	Khalgaon	840
19	Khaparkheda	420
20	Kolaghat	1260
21	Koradi	880
22	Korba STPS	2100
23	Korba West	840
24	Kota	850
25	Kothagudem	430
26	Mettur	840
27	Nasik	910
28	Neyveli	1770
29	Obra	1000
30	Panipat	750
31	Parli	630
32	Patratu	430
33	Raichur	440
34	Ramagundam	2100
35	Rihand	2000
36	Ropar	1050
37	Sanjay Gandhi	420
38	Santhaldih	480
39	Satpura Sarni	830
40	Singrauli STPS	1000
41	Talcher	1220
42	Trombay	1150
43	Tuticorin	1050
44	Ukai	850
45	Unchahar	420
46	Vijayawada	1260
47	Vindhyachal	1260
48	Wanakbori	1260
49	Cuddapah	420
50	North Chennai	630
51	Ib Valley	420
52	Dahanu	500

Independent power plants: location and capacity

Sl no.	Location	Capacity (MW)
53	Jegurupadu	235
54	Kakinada	208
55	Paguthan	635
56	Dabhol	744
57	Hazira	515

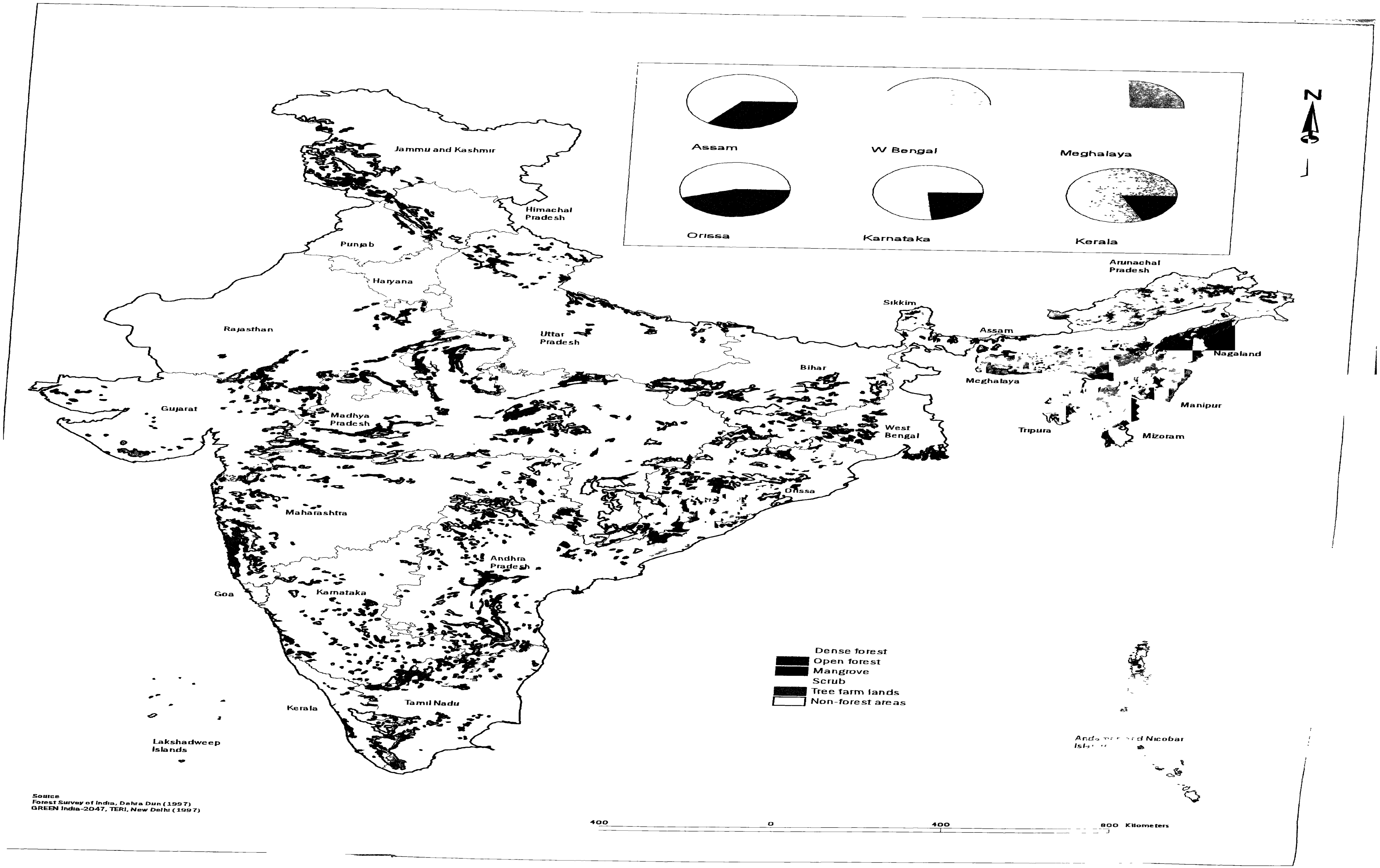
Hydel thermal plants: location and capacity

Sl no.	Location	Capacity (MW)
58	Bhakra	1100
59	Salal	460
60	Rana Pratap	172
61	Chibro	240
62	Ramganga	198
63	Pench	160
64	Bansagar	315
65	Koyna	920
66	Srisallam	770
67	Sharavathy	891
68	Varahi	230
69	Idukki	780
70	Kundah	555
71	Mettur	240
72	Hirakud	306
73	Balimela	360
74	Rengali	250
75	Kolab	320
76	Tanakpur	120
77	Lower Jhelum	105
78	A P Sahib	134
79	Rihand	300
80	Khodri	120
81	Chilla	144
82	Kadana	120
83	Gandhi Sagar	115
84	Jog	120
85	Supa	100
86	Loktak	105
87	Sanjay	120
88	Pong	360
89	Mukerian	195
90	Baira Siul	180
91	Chamera	540
92	Ukai	305
93	Sabaragiri	300
94	Kadamparai	400
95	Sileru	580
96	Machgund	115
97	Bhira	282
98	Kopili	100
99	Dehar	990
100	Nagarjuna	960
101	Kalinadi	810
102	Shanan	110
103	Hansdeo Bango	120



rce:
ergrid Corporation of India, New Delhi

Map 6. Powergrid map of India ([illegible] [illegible]) [illegible] kV and above



Source
Forest Survey of India, Dehra Dun (1997)
GREEN India-2047, TERI, New Delhi (1997)

Map 7. Forest cover in India by state (August 1999)

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